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USSR Report

ENGINEERING AND EQUIPMENT

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AERONAUTICAL AND SPACE

UDC 533.6.072

EFFECT OF SURFACE ROUGHNESS ON DRAG OF AIRCRAFT

Tbilisi SOOBSHCHENIYA AKADEMII NAUK GRUZINSKOY SSR in Russian Vol 122, No 2, May 86 (manuscript received 15 Mar 85) pp 358-360

[Article by R. I. Zukakishvili, A. M. Illarionov, and V. Ya. Belyayev, Georgian Polytechnic Institute imeni V. I. Lenin]

[Abstract] An experimental study of varnish-and-paint coated aircraft surface was made, for the purpose of determining the effect of the resulting surface roughness on the drag. Three parameters characterizing surface roughness had been identified as being aerodynamically significant, the first two being the mean asperity [profile peak] height over the sampling length and the density of asperities based on the mean distance between neighboring peaks, the third one referring to "maximally high" asperities (of heights more than 1.2 times the mean height) and defined as their mean height. Tests in a wind tunnel were performed on two composite models, with the ratio of mean overall asperity height to thickness of the aerodynamic boundary layer varied over the 0.0002-0.01 range and with sand grains attached to the surface to simulate large asperities of 180-700 μm height. The results reveal that even micro-roughness with a mean asperity height of 2-10 μm influences skin friction and drag. The friction coefficient was found to increase linearly with increasing mean asperity height and the magnitude of this increase to depend nonmonotonically on the density of asperities: first peaking fast with increasing density of asperities and then dropping slowly to a constant level in the "sandy" high-density range. Reducing the asperity height from 10 μm to 2 μm should result in a 2% lower fuel consumption. Polyurethane coating is suggested as an improvement over varnish-and-paint coating. Article was presented by M. V. Khvingiya, corresponding member of GSSR Academy of Sciences, on 14 March 1985. Figures 5; references 2: Russian.

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PRINCIPLES OF DATA DISPLAY IN AVIATION INSTRUMENTS

Moscow TEKHNICHESKAYA ESTETIKA in Russian No 4, Apr 86 pp 4-6

[Article by P. A. Kovalenko, psychologist, and V. M. Kuznetsov, engineer, Moscow]

[Abstract] Since electromechanical instruments used in civil aviation are no longer capable of supplying all the necessary flight data needed by the crew through the existing data display system, owing principally to the limited capacity of the instrument panel vis-a-vis the huge number of devices, each indicating a single parameter, three approaches have been considered for ergonomical updating of the hardware. The first approach, search for new engineering solutions such as use of multifunctional instruments with cathode-ray tubes or other displays, is a long-range approach and not relevant to the present status of civil aviation. The second approach, improvement of training methods and equipment, is limited by man's finite psychological and physiological capabilities. There remains the third approach, most promising, namely efficacious organization of data in composite instruments. Need for explanatory text should be avoided wherever possible, lest the display become overburdened and more time be required for taking readings with a higher probability of error. This is demonstrated on the KI composite indicator now showing the positions of elevators, rudder, stabilizer, ailerons, and spoilers. A redesign based on displaying the silhouette of the plane in foreshortened view "from behind" in such a way as to eliminate extra explanatory text except on the stabilizer scale, with one optimum foreshortening of all control surfaces and one standard graphic language, has resulted in the "modern" MKI version of this instrument with faster readout, lower error rate, and ease of memorization according to evaluation by professional and nonprofessional flight personnel. Using this new indicator in flight simulation tests has reduced the necessary number of actual test flights and thus saved 17,000 rubles worth of fuel so far. Figures 1; references 3: all Russian.

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EXPERIMENTAL STUDY OF SUPERSONIC STREAM SLIDING AT ANGLE PAST ONE-STEP WEDGE WITH JAWS

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 1, Jan-Mar 86 (manuscript received 12 Jan 83) pp 107-110

[Article by V. V. Duganov, N. N. Zakharov, and O. K. Ivanov]

[Abstract] A supersonic stream with Mach number N_M= 2.1 sliding at various angles of slide (0°, 5°, 10°) past a one-step wedge held between two identical

triangular lateral jaws with various flare angles (20°, 30°, 39°18') was studied experimentally in a wind tunnel, with the Reynolds number $N_R \approx 10^8$ referred to a 1 m long characteristic dimension and with the stagnation temperature T_s = 288 K. The flow patterns were visualized with the aid of an IAB-451 optical interferometer and the static pressures were measured with a GRM P-99 recording group manometer. The pressure profiles indicate a streamlining of the jaws in a plane perpendicular to the front edge, by a stream sliding at a nonzero angle, with the angle of attack increasing as the stream sliding angle is increased and as the jaw flare angle is decreased. The results suggest ways to minimize the nonuniformity of flow parameters and to prevent separation. Figures 4; references 5: 4 Russian, 1 Western.

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UDC 533.6.071.1:535

STRUCTURAL ANALYSIS OF SUPERSONIC JET DISCHARGING FROM FREE-VORTEX NOZZLE BY METHOD OF HOLOGRAPHIC INTERFEROMETRY WITH PULSED LASER

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 1, Jan-Mar 86 (manuscript received 25 Mar 85) pp 105-107

[Article by V. I. Panchenko, A. A. Gilerson, and B. S. Vinogradov]

[Abstract] The structure of a real jet discharging from a free-vortex nozzle, ideally representing a steady potential two-dimensional flow with concentric circular streamlines, was analyzed with an IAB-451 interferometer according to the classical scheme and also in the holographic modification. Holograms were recorded with an OGM-20 pulsed laser (λ = 0.6943 μm wavelength, pulse width t = nsec) by the method of two separate exposures, accessories including two polarizer plates, four objectives, and eight mirrors. A jet under nominal conditions and a dispersing jet, with the radial pressure profile nonuniform and peaking at the axis, were examined by this method as well as on the basis of classical interference and shadow patterns. The results have been calibrated against differences between a real jet and an ideal one, namely differences in density at the jet boundary with attendamt boundary layer buildup. Figures 4; references 4: 3 Russian, 1 Western.

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UDC 552.517.4:518.12

MATHEMATICAL MODEL DESCRIBING INTERACTION OF SINGLE NONSTEADY SUPERSONIC JET AND MOVABLE BARRIER OF FINITE DIMENSIONS

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 1, Jan-Mar 86 (manuscript received 20 Apr 85) pp 99-102

[Article by A. V. Kuznetsov]

[Abstract] Interaction of a single nonsteady supersonic jet and a movable barrier of finite dimensions, characterizing the gas generator process with a shock-wave effect, is described mathematically by two systems of partial differential equations of motion for a gas with an algebraic equation of its state in an idiabatic process and an ordinary differential equation of motion for a solid. The system of three equations describing the flow inside the gas generator is quasi-one-dimensional with time as second variable. The system of four equations describing axisymmetric flow outside the gas generator as an adiabatic and isentropic process is two-dimensional in cylindrical coordinates with time as third variable. The problem has been solved by the predictor-corrector method with second-order precision in space and time, taking into account the geometry of gas generator and barrier. The results agree satisfactorily with experimental data, indicating an almost universal validity of this mathematical model. Figures 2; references 8: 7 Russian, 1 Western (in Russian translation).

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UDC 536.68:536.3

SIMULTANEOUS RADIATIVE AND CONVECTIVE HEATING OF 'THIN' BODY IN MEDIUM WITH VARIABLE TEMPERATURE

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 1, Jan-Mar 86 (manuscript received 15 Jan 85) pp 88-90

[Article by Yu. V. Vidin]

[Abstract] Heating of a thermally "thin" body by a source at a variable temperature through a medium which tranmits heat simultaneously by radiation and convection is described by a general transient-state equation for the rate of change of the body temperature with two terms, a Stefan-Boltzmann term and a Newton term, on the right-hand side. This first-order differential equation is put in dimensionless form including the Fourier number as well as the Stark number and the Biot number, with retention of the body form factor (Γ = 1,2,3 for plate, cylinder, sphere respectively). A rigorous analytical solution of this equation is shown to be possible when the heater temperature satisfies a certain fourth-order algebraic equation with ratio $p = N_{Bi}/N_{Sk}$ and product $m = N_{Bi}N_{Fo}$ as parameters. References 2: Russian.

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CSO: 1861/445

UDC 621.515

DEVELOPMENT OF MODEL DESCRIBING UNSTABLE OPERATION OF TURBOCOMPRESSOR AND DESIGN OF ANTISURGING PROTECTION FOR GAS TURBINE ENGINE

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 1, Jan-Mar 86 (manuscript received 19 Jun 85) pp 61-66

[Article by M. M. Shakiryanov]

[Abstract] Unstable operation of an acoustic mechanical system which consists of a turbocompressor and a receiver with connecting pipes and a throttle is described by a mathematical model which includes four equations of state for air as an ideal gas in each of four locations within the system. On the basis of this model are established the surge characteristics of such a system, its stability region according to the Hurwitz criterion, and the conditions for gas dynamic stability. A pneumoelectronic system is then designed accordingly for protection of a gas turbine engine against surges. The system consists of three pressure transducers and one temperature transducer, two threshold devices, two computers and a function converter, and three final control elements between engine and guide vane array, engine and air bypass, engine and fuel cutoff valve. Figures 5; references 6: all Russian.

2415/12947
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UDC 681.51.015

IDENTIFICATION OF FREQUENCY CHARACTERISTICS DURING LABORATORY TESTS

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 1, Jan-Mar 86 (manuscript received 20 Feb 85) pp 47-52

[Article by I. Kh. Sadykov]

[Abstract] Identification of a test object's frequency characteristics during laboratory tests is necessary for automation of data processing during such tests. This can be done by analysis of the transient response to a unit step input signal rather than by application of numerous sinusoidal input signals. The algorithm is based on Fourier integral transformations of input and output functions. It is necessary, however, to identify the model of the test object first before the frequency characteristic of the object can be identified. The algorithm is accordingly an iterative one with a recurrence procedure, and also an adaptive one for improvement of the accuracy. References 4: 3 Russian, 1 Western (in Russian translation).

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UDC 621.45.022.2

CATASTROPHIC BREAKUP OF LIQUID JET BY SUBSONIC TRANSVERSE GAS STREAM

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 1, Jan-Mar 86 (manuscript received 20 Dec 84) pp 42-46

[Article by M. Ye. Rudyak]

[Abstract] Various possible mechanisms of Rayleigh-Taylor instability at the liquid jet and gas stream interface, resulting in breakup of the jet, are analyzed on the basis of experimental data. Measurements were made in a special mixing channel by the electrical contact method, a gradual or jump increase of electrical resistance between the orifice and the probe moved along the outer jet boundary indicating respectively a smooth or sudden breakup of the jet. The results against effective methods of atomizing a liquid jet, namely application of a dynamic pressure load in cantilever fashion or application of such a load together with sharp bending of the jet. Gas injection from a recess in the mixer wall or from behind the threshold of a step diffuser is also effective, final breakup of the jet occurring in the form of "minor" catastrophe after the "major" one. Figures 3; references 13: 6 Russian, 7 Western.

2415/12947
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UDC 621.43.056:536.24:532.54

CALCULATION OF AXISYMMETRIC FLOW IN SWHIRLERS BY DIFFERENCE METHOD

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 1, Jan-Mar 86 (manuscript received 23 Jul 85) pp 25-29

[Article by V. N. Ignatyev]

[Abstract] A difference scheme with exponential fitting is proposed for solution of the system, of Navier-Stokes equations describing steady axisymmetric flow with rotation through a cylindrical swhirler (vortex generator) with a parabolic radial profile of the flow function in the entrance section and with "soft" boundary conditions at the exit. Such a difference scheme is of "highest"-order precision and monotonic, designed for differential equations with a small parameter as coefficient of the higher-order derivatives. The scheme is implementable upon introduction of the "difference" Reynolds number on the basis of a theorem which ensures monotonicity at any value of the Reynolds number $N_R > 0$ when $\bar{r}_j v_i h_j \leq 1/N_R$ ($\bar{r}$- discrete segment of radius, v_{ij}- axial velocity). Calculations according to such a scheme with 10x20 or 20x40 grids and with stabilizing correction on a YeS-1033 computer indicate that this method is both efficient and accurate for low and high values of the Reynolds number, the machine time depending on the Reynolds number. Figures 4; references 6: 4 Russian, 2 Western (1 in Russian translation).

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UDC 534.1

EFFECTIVENESS OF BALANCING FLEXIBLE ROTARY COMPRESSOR VANES ON LOW-SPEED BALANCING MACHINE

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 1, Jan-Mar 86 (manuscript received 25 Apr 85) pp 15-19

[Article by A. I. Gleyzer and V. A. Bulychev]

[Abstract] Low-speed dynamic balancing after preliminary static balancing and correction of a flexible rotary compressor vane is analyzed, such vanes consisting of several wheel pairs on a common shaft. The unbalance and thus necessary correction are calculated on the basis of the classical equation for dynamic deflection of a beam on two bearing supports with stiffness and viscous damping, both orthogonal component of that deflection being represented as combinations of A. N. Krylov's functions and definite integral. The general solution, including a probability factor, is evaluated so as to yield the bearing vibration velocity after dynamic correction as a function of the operating speed with the coefficient of viscous damping in the bearings as parameter. On the graph of this relation can be readily indicated the range of operating speeds between acceptable minimum and permissible maximum vibration velocity. Figures 2; references 4: all Russian.

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UDC 533.607.11

COMPRESSIBILITY OF SUBMERGED SUPERSONIC JETS

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 1, Jan-Mar 86 (manuscript received 27 Sep 84) pp 11-15

[Article by S. I. Baranovskiy, A. S. Nadvorskiy, and T. F. Savina]

[Abstract] Flow of a supersonic molecular gas jet discharging into an air stream is analyzed theoretically on the basis of the applicable equation of continuity, equations of conservation (momentum, energy mass), and equation of state for each chemical element as an ideal gas. Compressibility during turbulent mixing is taken into account by replacement of the mass transfer coefficients with their effective turbulent analogs. Calculations based on the $K\varepsilon - 1$ turbulence model are compared with experimental (L.J.E. Broer and J.A. Rietdijk, T.R. Troutt and D.K. McLaughlin, J.M. Eggers, E.T. Pitkin and J. Glassman). The results yield a correction for compressibility with which the eddy viscosity becomes a function of the Mach number at the nozzle throat for a supersonic jet best fitting the empirical relation $C_\mu = 0.09 - 0.04\frac{\Phi}{N_M}$ (Φ- function of mixing length, of velocity at jet axis, and of velocity change along jet radius). Figures 4; references 11: 4 Russian, 7 Western (1 in Russian translation).

2415/12947
CSO; 1861/445

UDC 621.438

FLOW OF GAS THROUGH TURBINE STAGE WITH SPHERICAL NOZZLE SEGMENT

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 1, Jan-Mar 86 (manuscript received 23 Jan 85) pp 8-11

[Article by A. I. Arkhipov, M. K. Maksutova, and Yu. V. Strunkin]

[Abstract] A gas turbine stage with a spherical adjustable nozzle is considered in lieu of a conventional cylindrical one so as to avoid variation of the radial clearance in the meridional section and hold it to a minimum during rotation of the vanes. An analysis of the flow through such a turbine stage based on equilibrium and dynamics of compressible flow, assuming concentric streamlines and uniform radial profiles of the stagnation parameters, reveals that the energy losses increase appreciably from the root to the periphery of vanes with a profile of the loss coefficient over the channel height depending on the variation in entrance angle. Figures 2; tables 1; references 1: Russian.

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UDC 621.31

POWER GENERATING COMPLEXES AND GAES (STATUS AND PROSPECTIVES)

Kiev ENERGETIKA I ELEKTRIFIKATSIYA in Russian No 2, Apr-Jun 86 pp 45-48

[Article by Corresponding Member, Academy of Sciences UkSSR, A.N. Podgornyy and Candidate of Technical Sciences L.Ya. Stanislavskiy, IPMash, AN UkSSR]

[Text] Power Generating Complexes [1]. Development of powerful energy generating complexes, that combine, both territorially and technologically, nuclear and hydroelectric power plants and use complex duty water reservoirs, is one of the most efficient new trends in the development of power industry. It makes it possible to achieve considerable savings of capital investment and material and labor resources, as well as to reduce the overall level of environmental impact of power plants construction.

Creation of power generating complexes has a number of advantages:

- combined multi-purpose utilization of facilities and infrastructure, as well as water, land and other resources;

- complex solving of environmental protection problems;

- reduction of construction periods and labor expenditures during construction;

- reduction of operational expenses, including reductions due to the reduction in operating personnel.

Savings of adjusted expenditures, due to creation of one power generating complex, are not less than 25-30 million rubles, plus reduction of condemned land areas and water consumption.

The first such power generating complex, the South Ukraine complex, that consists of the South Ukraine AES, Tashlyk GAES [hydroelectric pumped storage power plant] and Konstantinovka GES-GAES, is under construction. It is characterized by high economic efficiency.

Savings of adjusted calculated expenditures for construction of power generating complexes, compared to separate construction of power sources, are determined from the following formula (see next page):

$$\overline{З} = \overline{K}\overline{E}_н + \overline{И},$$

where $\overline{З}$ are savings of adjusted calculated expenditures, million rubles; $\overline{K}$ are savings of adjusted capital expenditures, million rubles; $E_н$ is a standard efficiency ratio ($E_н$ =0.12), based on ROI term of 8.3 years; $\overline{И}$ are savings of annual expenditures, million rubles.

The Ukrainian department of "Gidroproekt" Institute is looking for new sites for possible location of power generating complexes.

Manufacturing of Hydraulic Turbines in Kharkov [2, 4]. Creation of 310 MW hydraulic turbines, designed for up to 275 m head, and of 4.2 m diameter ball locks for the Nurek GES is an important benchmark in the development of hydraulic turbine manufacturing in Kharkov. Now the "Kharkovskiy turbinnyy zavod" Association has released the pilot model of a high-head Kaplan hydraulic turbine for the Shulbinsk GES, 230 MW, 93.8 rpm. Production of a unique 615 MW radial-axial hydraulic turbine for the Rogun GES with cylindrical lock for operation at heads of up to 320 m, is in the preparation stage.

Creation of GAES and convertible hydraulic machines therefor is a new trend in the development of domestic hydraulic power industry. The operational experience of the Kiev GAES revealed a number of problems in operation of convertible units.

Therefore the "Kharkovskiy Turbinnyy Zavod" Association, together with a number of NII [scientific research institutes], is performing a complex of NIR [scientific research works] on development of efficient straight-flow components for convertible hydraulic machines. In the 12th five-year plan, delivery of a number of the largest convertible hydraulic machines with high unit capacity to the Dnestrovsk GAES is scheduled. Delivery of the first domestic convertible diagonal type hydraulic machine to the Konstantinovka GAES is also scheduled. This machine will be operating at 19-42 m heads.

Now the Laboratory of Convertible Hydraulic Machines of the Problems of Machine Building Institute, AN UkSSR, together with POAT "KhTZ" [Kharkov Tractor Plant] have developed highly efficient models of straight-flow components for convertible hydraulic machines of the radial-axial type, with heads up to 200 m. Energy-cavitation parameters of these machines are at the same level, as those parameters of the best foreign models.

Kharkov Hydraulic-Turbine Generators and Convertible Hydraulic-Turbine Generators-Motors [4]. At the "Elektrotyazhmash" plant 57.2 MW, 62.5 rpm hydraulic-turbine generators for a number of GES were built, including generators for the Kremenchug GES, that were designed for operating without a machine room building. In recent years, 105 MW, 107.1 rpm generators for Dnyeproges-2 and the Dnestrovsk GES were built. The first domestic 41.5 MW, 166.7 rpm generators-motors of the Kiev GAES, have been in operation since 1969.

For the first time, the plant and NII "Energotyazhmash" have designed and built four generators-motors, 209/220 MW each (Figure 1), for "Zharnovets" GAES in the Polish People's Republic. After comprehensive full-scale tests, conducted together with professionals from "Energopomyar" (PPR), the generators-motors were put in operation.

GAES Development [3, 4]. After WW II GAES have been widely used in the USA, Japan and West European countries. GAES share in these countries' power systems is anywhere from 4 to 10%.

The Soviet Union is the world's leading country in the development and operation of hydraulic-turbine generators for regular GES. 500 MW generators at the Krasnoyarsk GES and 640 MW generator at the Sayano-Shushenskiy GES etc. have long been in operation.

GAES have not yet received due development in the USSR. Scientists and designers have to solve a number of new problems, that have emerged.

Today a number of powerful GAES are under construction in the USSR: Zagorsk, total capacity 1,320 MW, Kashyadoris, with the same capacity, and others, including GAES, that are part of South Ukraine, Dnestrovsk and other power generating complexes.

One of the most important problems in creating large GAES is the absence of an acceptable method for starting powerful convertible GAES units in the pumping mode. As is well known, a convertible hydroelectric GAES unit, that consists of an electrical machine and a hydraulic turbine, operates in two modes.

The first is a generating mode, wherein a hydraulic unit operates as a turbine, using the energy of water, accumulated in the upper pond, and turns an electrical generator, that supplies power to a power network. In this mode, a GAES generator is not at all different from already mastered generators of regular GES.

The second is a pumping mode, wherein the unit receives electrical power and pumps water from the afterbay into the upper pond. This mode requires starting a powerful unit, with the weight of rotating parts of 1,000 tons and more. In the case of direct starting of a unit from a power network, the power network and the unit are subjected to intolerably hard working conditions.

In 1974-1978 the authors studied data on starting, operation, inspection and testing of GAES: 41 in the USA, 19 in Japan, 19 in FRG. At these GAES various methods for starting convertible generators-motors in the pumping mode were used. The following has been determined:

Direct starting at full network voltage (P) is the most economical method, but it is necessary to beef up the core, the synchronous machine stator windings and the modular transformer. Network-related limitations arise.

Asynchronous starting at a reduced voltage (AP) is expensive and has some of disadvantages of the P method. It is used at a number of GAES in the USA and Japan for 110-140 MW units.

Starting by a starting motor (D) is expensive, has a relatively long starting time and requires an increase in GAES machine room height.

Frequency starting by a synchronous generator (Ch). In this case a unit starts rotating smoothly, without shocks. However, application of the Ch method is deterred by the need to have on hand free synchronous generators. Synchronous generator power, required for starting the rotation of a GAES unit, is about 15% of power of the rotated unit.

Thyristor starting (T). A new progressive method for starting GAES units is a system for thyristor starting by a static frequency converter. Schematic diagram of thyristor frequency starting of powerful synchronous motors is presented in Figure 2.

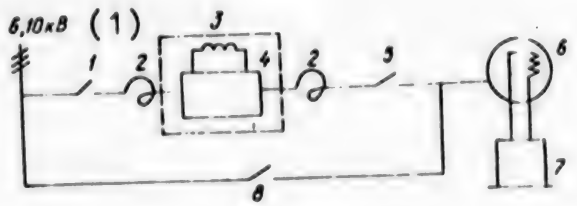

Figure 2. Schematic Diagram of Thyristor Frequency Starting of Powerful Synchronous Motors

Key:
1. 6.1 kV

During the starting process, a synchronous motor with excitation system supplied from static exciter 8 gets power from thyristor frequency converter 4; in this case switches 5 and 1 are closed, and switch 8 is open. After the motor has been accelerated to the synchronous speed, using the exact synchronization method, switch 8 closes, the motor gets power from the network, and switches 5 and 1 open.

Voltage at the thyristor frequency converter output changes, both in amplitude and frequency, from zero at the beginning of the starting period, according to the law $\frac{U}{f}$ = const, and the motor immediately starts operating in the synchronous mode. As a rule, the motor starting torque M_{start} does not exceed (10-15)% of the nominal torque M_{nom}. In this case the motor current is equal to $I_{START} \approx I_H \frac{M_{START}}{M_H}$.

Thus, during the starting period, up to the moment of connecting the motor to the network, the motor current and, correspondingly, the current, consumed from the network, is limited to $(0.1\text{-}0.15)I_{nom}$; as a result, there are no extreme thermal and electrodynamic loads on the motor and no current shocks in the supplying network, which are characteristic for direct or reactor starting. Due to this fact, the number of startings is not limited.

A thyristor frequency converter is a static device, that consists of panels with semiconductor equipment. The equipment includes concrete reactors 2 and smoothing reactor 3. The converter power equals to the motor starting power at the end of the starting period.

A problem has come up: develop a new perfect method for starting powerful units, the so called thyristor starting, as the most progressive and promising method for the largest hydraulic generators-motors for GAES. The method must provide smooth starting of a unit, without shocks, that are hard on the power network, and without mechanical and electrodynamic overtension of GAES unit components.

In creative cooperation of the Academy of Sciences UkSSR and Kiev GAES, a prototype system for thyristor starting of GAES units has been developed and tested on one of generators-motors.

A factory had built and delivered to the Kiev GAES a mine-panel thyristor frequency converter, together with a protection and signalling device.

Comprehensive tests of the thyristor starting system were performed; they yielded positive results in the case of starting a unit with a dryed chamber. A 41.5 MW unit was successfully and smoothly accelerated from zero to the synchronous rotational speed of 166.7 rpm in about 300 s. Power consumption equalled 1,350 Kw.

The tests proved, that in the process of developing the new system all technical problems, related to starting GAES hydraulic units, have been solved. At the same time the tests demonstrated, that if, during the manufacturing and assembling of the hydraulic machine components, drying of its working chamber is not provided (there are water leakages), power consumption by a motor increases approximately tenfold. This was explained by tremendous leakages through a closed nozzle. The test results should be taken into account in developing hydraulic machines for GAES and systems for starting thereof.

Using the experience in the development and studying of thyristor starting of a unit at the Kiev GAES, it has been decided to use this method for starting turbine generators at TETs-4 and GRES-2, PEO "Kharkovenergo", with turbines dismantled. For thyristor starting thereof, serial frequency converters of the PChV-6000-400-50/3, supplied for using synchronous electrical machines at metallurgical plants, are used. They were commissioned at TETs-4 at the end of 1983 (Figure 3).

In the recent years, the system for thyristor starting of a generator-motor is ever widely used. In England such system is used at the Dynorwick GAES with

six 300 MW units, in the USA it is used at the Rockoon GAES with four 402 MW units, in Japan it is used at the Okuyoshino GAES with six 207 MW units; it is also used at other foreign GAES [5].
In our country the thyristor starting system is contemplated for six 220 MW units, at the Zagorsk and Kayshyadoris GAES, both under construction, for 207 MW units of the Tashlyk GAES, which is part of the South Ukraine power generating complex, and for the Dnestrovsk GAES with units over 300 MW each, which is a part of the Dnestrovsk power generating complex. A similar system is implemented for starting 50 MW turbine generators (with turbines disnatled) at the Nesvetay GRES.

Conclusions

1. One of the new efficient trends in the development of power industry is creation of powerful power generating complexes, that combine, both territorially and technologically, nuclear, thermal and hydroelectric power stations.

2. The most promising method for starting powerful convertible GAES units in the pumping mode is thyristor frequency starting.

3. In order to successfully conduct the required scientific research and experimental design works, including correct selection of safety margins for GAES units with consideration given to multiple transient modes thereof, and in order to assure further progress in the development of power units for GAES, it is mandatory to wider enlist the scientific potential of the Republic in the development of turbines-pumps and hydraulic generators-motors.

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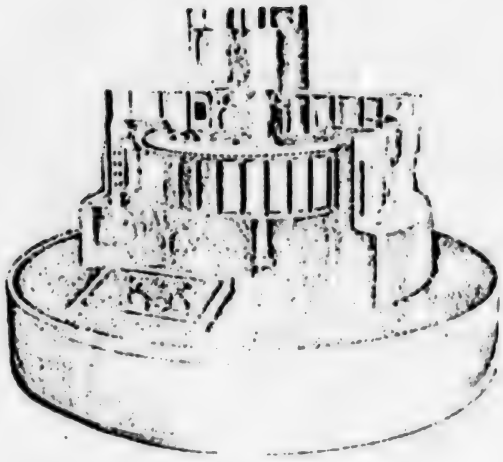


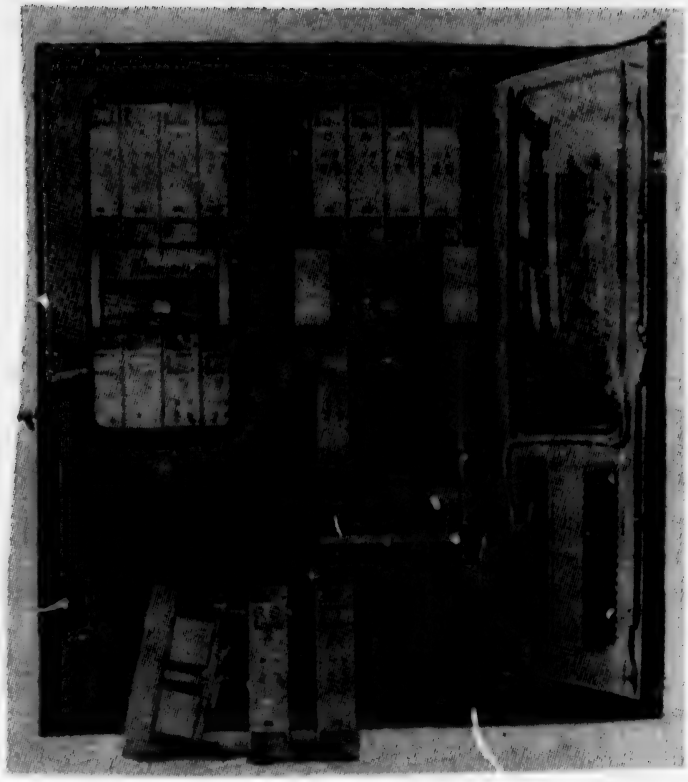


Figure 1 (left). 209/220 MW, 166.7 rpm Hydraulic Generator-Motor, Manufactured by "Elektrotyazhmash" Plant for "Zharnovets" GAES (PNR)

Figure 3 (right). PChV-6000-400-50/3 Type Gate Thyristor Frequency Converter, Installed at Kharkov TETs-4 for Starting Turbine Generators, Used as Synchronous Compensators (Turbines Dismantled)

12770/12947
CSO: 1861/467A

EXPERIENCE OF ADOPTING SVD-VTI-YuTE ASH TRAPS

Moscow ENERGETIK in Russian No 4, Apr 86 pp 14-15

[Article by Doctor of Technical Sciences L. I. Kropp, Candidate of Technical Sciences M. S. Kharkovskiy, engineer G. A. Konshin, engineer Ye. T. Durovskiy and engineer Ya. D. Vasylyna, All-Union Heat Engineering Institute imeni F. E. Dzerzhinskiy, Yuzhtekhenergo]

[Text] Implementing the norms of the maximum permissible and time-coordinated discharges of noxious materials into the atmosphere and also conversion of the GZU [hydraulic ash removal] systems of power plants to the circulating water supply impose increased requirements on the operating reliability of wet ash traps and on the efficiency of scrubbing the gases in them.

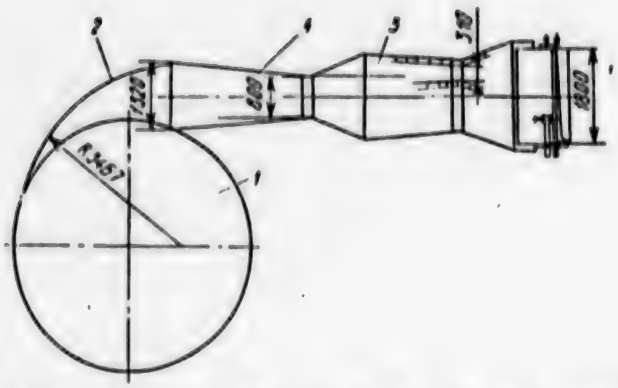
These requirements are especially timely for power-generating units with capacity of 150-200 MW, equipped with large unit-performance wet ash traps for scrubbing flue gases of finely dispersed, highly concentrated ash.

This ash is formed when buring Donetsk and Lvov-Volynsk coal, crushed in ball drum mills. The efficiency of trapping in standard wet MV and MS apparatus does not exceed 95 percent.

Moreover, when burning coal, distinguished by high ash and sulfur content, intensive abrasive-corrosion wear of the coagulated walls and of the inlet sections of the housing of wet ash traps is observed.

These problems were solved with development of the SDV-VTI-YuTE wet ash trap, in which the results of research and development of VTI imeni F. E. Dzerzhinskogo [All-Union Heat Engineering Institute imeni F. E. Dzerzhinskiy] and Yuzhtekhenergo [not further identified] were used.

The SVD-VTI-YuTE apparatus (see figure) consists of a two-stage rectangular Venturi coagulator (KV) of transverse section and of a drop trap 1, installed at a slight gradient to the horizon. The first stage 3 of the Venturi coagulator is two-sectional. Four nozzles, designed by Yuzhtekhenergo, were installed in the gas duct in front of it. The diffuser 4 of the second stage of the Venturi coagulator is connected to the drop trap by helical inlet pipe union 2. The side walls of the coagulators are made of acid-resistant brick. The design is sufficiently compact for installation at power-generating units upon modification of ash traps.



SVD-VTI-YuTE Wet Ash Trap With Two-Stage Venturi Coagulator

SVD-VTI-YuTE apparatus was used at three power-generating units with capacity of 200 MW of the Moldavian GRES. The first models of this apparatus were introduced at the GRES in May 1982. The experience of operating them showed that the use of acid-resistant brick in their development permitted a significant reduction of expenditures for routine repairs. There is every basis to assume that this protection will ensure reliable operation of the ash traps during the period between major overhauls of the boilers.

The walls of the modified ash traps, despite the operation of the GZU system on a completely closed cycle (as a result of this, the clarified circulating water from the ash pit of the Moldavian GRES is supersaturated with calcium sulfate) were not encrusted with gypsum ($CaSO_4 \cdot 2H_2O$) deposits. This is explained by the fact that approximately 20 percent of recycled water was mixed with the circulating water going to irrigate the ash traps at the recommendation of VTI and Yuzhtekhenergo. Since approximately the same fraction of water was evaporated in the ash traps, mixing did not result in the appearance on the ash pit of excess clarified water, which had to be dumped into natural reservoirs.

Sector acceptance trials of SVD-VTI-YuTE equipment were conducted in October 1984 at the power-generating unit, plant number 5, Moldavian GRES. The main results of the tests are presented below:

Fuel	Mixture of Donetsk coal
Steam output of boiler, t/hr	608-612
Reduced ash content of fuel, percent/(MJ/kg)	1.3-1.45
Air intakes into ash traps	0.027-0.047
Exhaust gas temperature, °C:	
in front of ash traps	155-162
after ash trap	67-69
Volumetric flow rate of flue gases per ash trap, thousand m³/h	up to 280
Total hydraulic resistance of ash-trapping unit, Pa	1430-1550*
Degree of scrubbing of flue gases, percent	97.3-97.7

Specific mass water consumption for gas scrubbing (under normal conditions), kg/m³	0.189-0.229
Specific electric power consumption for scrubbing flue gases (under normal conditions), kW·hr/1000 m³	0.813-0.846

*Increased hydraulic resistance of SVD-VTI-YuTE equipment at given power-generating unit was caused by increased air intake into boiler and by flue gas flow rates up to 280 thousand m³/hr instead of 240-250 thousand m³/hr, compared to other power-generating units.

The flue gases are cooled by an average of 90°C in the apparatus at irrigating water flow rates that provide a degree of gas scrubbing of approximately 97.5 percent. As the tests showed, this cooling can be reduced to 75°C by reducing the water flow rate for irrigation, but the degree of gas scrubbing decreases below 97 percent.

The permissible temperature of the scrubbed gasses when burning Donetsk coal is 65-70 °C; therefore, it is recommended that new equipment be used in boilers, the exhaust gas temperature t_{yx} beyond which is less than 150 °C. The scrubbed gases can be heated to approximately 70°C at lower values of t_{yx} (for example, heating of cooled gases to a temperature not less than 72°C at a thermal power plant prior to discharge in the atmosphere is regulated by law in the Federal Republic of Germany).

A saving of 57 thousand rubles annually was achieved at each power-generating unit of the Moldavian GRES due to a reduction of expenditures for repair of the lining of the ash traps alone.

Conclusions

1. As a result of development and long verification of new ash traps during bench investigations, industrial trials and adoption of apparatus at the Moldavian GRES, their high technical and economic indicators were confirmed and the recommended area of application was determined.

2. SVD-VTI-YuTE apparatus should be used for technical retooling of electric power plants, primarily for power-generating units having capacity of 150-200 MW, which burn high-ash and high-sulfur coal (Donetsk, Lvov-Volynsk), and also wastes for concentrating it. The coal should be used at exhaust gas temperatures above 140°C for more complete realization of the advantages of the apparatus. The use of the apparatus is feasible at lower values of t_{yx} provided that the scrubbed gases are heated, for example, by mixing 5-6 percent of the surplus fuel air from the boiler with them.

3. Working out rational conditions for the circulating water supply of new apparatus during operation of the GZU system on the nondrainage principle permits integrated solution of the problems of improving the reliability and efficiency of the wet ash trap.

6521 /12947
CSO: 1861/521

EXPERIENCE IN DEVELOPMENT OF STORAGE FACILITIES FOR SPENT NUCLEAR FUEL

Moscow ATOMNAYA ENERGIYA in Russian Vol 60, No 6, Jun 86 pp 429-431

[Article by I. L. Rybalchenko]

[Abstract] The conference held in September-October 1985 in Otaniemi (Finland) by the IAEA's Technical Committee on Design of Storage Facilities for Spent Nuclear Fuel dealt with basic principles and criteria of reliability and safety assurance. The technology of on-site storage in underwater pools has proven itself and become generally accepted, wet storage in closed cans or open bins being preferable to dry storage in concrete drums. Specialists from the U.S., Japan, Finland, West Germany, Switzerland, Czechoslovakia, and Hungary reported on their experience, problems, and solutions. Water conditioning and introduction of neutron absorbers such as boron increase the storage capacity and reduce the cost of structural materials for waste containers. Special design of containers with hermetic sealing and corrosion-resistant lining improves reliability and safety. Design should be based on a 0.95 neutron multiplication factor, and the actual depletion of fission fuel should be taken into account so as to avoid overestimation of size and cost of storage facilities. The economics of waste storage is becoming an important factor in further development of various alternative methods.

2415/12947
CSO: 1861/483

UDC 621.311.25:621.039.662.96

DEVELOPMENT OF HIGH-EFFICIENCY FILTERING AND VENTILATING EQUIPMENT IN NUCLEAR POWER PLANTS FOR REMOVAL OF RADIOACTIVE AEROSOLS AND IODINE FROM AIR

Moscow TEPLOENERGETIKA in Russian No 7, Jul 86 pp 12-14

[Article by F. Ya. Ovchinnikov, candidate of technical sciences and director general, MKhO [International Economic Union] of Interatomenergo]

[Abstract] In nuclear power plants with VVER-440/1000 MW PWR it was until recently necessary to install air filters originally designed for other industries and not quite adequate for a radioactive environment, especially under conditions of high humidity at temperatures up to 100°C and during

seismic activity with readings up to 9 on the MSK-64 scale. To remedy this problem, Soviet and Czechoslovak enterprises in coordination with the MKhO of Interatomenergo have developed a line of filter-ventilator units adequate for this special purpose. They are "rough" air prepurifying filters and "absolute" high-efficiency filters, the latter including filters for removal of solid and liquid aerosols, filters for removal of radioactive iodine and its compounds, with air preheaters for lowering the prefilter humidity level, and filters for removal of water mist and droplets. Their design is modular, for buildup to 1700, 5100, 10,200, 15,300, and 20,400 m^3/h capacity. The functional and structural modules are aerosol-trapping insert plates (292x610x610 mm^3), water-trapping insert plates (150x610x610 mm^3), vertical cylindrical sorption cartridges, and heating rods. The nominal operating rarefaction is 6000 Pa and the pressure drop at the nominal air flow rate does not exceed 1500 Pa. These units trap radioactive aerosols with at least 99.95% efficiency and radioactive iodine compounds such as CH_3I-131 with at least 99% efficiency. Remote temperature and overpressure monitoring will be provided, also regulation of heater power to ensure that the relative humidity of air entering the iodine traps does not exceed 90%. Figures 3.

2415/12947
CSO: 1861/519

UDC 533.601.312

AERODYNAMIC CHARACTERISTICS OF TRILOBAR WATER-COOLING TOWER

Novosibirsk IZVESTIYA SIBIRSKOGO OTDELENIYA AKADEMII NAUK SSSR: SERIYA TEKHNICHESKIKH NAUK in Russian No 10, Issue 2, Jun 86 (manuscript received 23 Apr 84) pp 64-71

[Article by V. M. Kovalenko, Institute of Theoretical and Applied Mechanics, Siberian Department, USSR Academy of Sciences, and V. V. Larichkin, Siberian Scientific Research Institute of Power Engineering, Novosibirsk]

[Abstract] A new design of a water-cooling tower, tapering from the ground up with a flare at the top in the elevation view and three identical lobes with axes 120° apart in the plan view, is evaluated in terms of wind loading. The analysis is based on model tests in a horizontal wind tunnel with an air stream flowing at velocities up to 31.2 m/s and with the Reynolds number varying from $2.6 \cdot 10^5$ to $8.9 \cdot 10^5$, a scaled-down model in vertical position being rotated so as to face the air stream at various angles, flow patterns being visualized with the aid of silk threads, and pressure being measured with an alcohol micromanometer as well as with a DMI-0.1 inductive pressure transducer. The measurements have yielded the azimuthal distribution of the pressure coefficient depending on the angle of attack and on the wind velocity. These measurements and visualization reveal an intricate streamlining pattern with separation zones, its strong dependence on the wind direction and weak dependence on the Reynolds number within the given range, also a nearly uniform pressure distribution over the tower height. The pressure coefficient and the transverse aerodynamic forces on the tower overall, as well as on each lobe, is a maximum at ~40°angle of attack. Figures 8; references 13: 10 Russian, 3 Western.

2415/12947
CSO: 1861/528

UDC 621.039.534.4.25:532.529.5

TRANSIENT PROCESSES IN LOOPS OF NUCLEAR REACTOR

Moscow ATOMNAYA ENERGIYA in Russian Vol 60, No 4, Apr 86 (manuscript received 4 Feb 85) pp 255-258

[Article by Yu. V. Mironov, N. S. Razina, and T. I. Fomicheva]

[Abstract] Normal and fault transients in a nuclear reactor are analyzed on the basis of a boundary-value problem for the system of differential equations describing flow thermodynamics and heat transfer in the coolant circulation loops. As physical model has been selected one which includes superficial evaporation of underheated water as well as film boiling in a two-phase medium. The mathematical model consists of the three equations of mass balance, momentum balance, energy balance, an equation of heat balance in the liquid phase, an equation of heat conduction in a fuel element, and empirical closing relations for slip and friction in a two-phase stream. Solution of this system of equations for the appropriate boundary conditions is possible according to the TRANS7 algorithm of numerical integration specially designed for this purpose. It applies to nonequilibrium flow of a two-phase medium, with the state of the liquid phase not necessarily identical to that of boiling water, and assuming that all processes are sufficiently slow in comparison with the speed of sound. The boundary conditions are stipulated in terms of pressure, with or without flow rate, and enthalpy at both ends of the channel. The thermophysical properties of the medium throughout the channel are at every instant of time determined by some base pressure, the latter being a function of time. The channel consists of segments with different diameters joined by drag risers, heat evolving in each segment at a rate which is a priori given and is generally a function of time. The equations of balance are solved by a "hybrid" method which combines implicit finite-difference schemes for mass balance and momentum balance with "characteristics" for energy balance and heat balance. The algorithm yields, as intermediate quantity, the heat transfer coefficient. It was tested against a physical experiment, the object being an electrically heated 13.6 m long made of stainless steel with an inside diameter of 16 mm and a wall thickness of 3 mm. The agreement was close for purely convective heat transfer, not so close for convective heat transfer with boiling and superheating. In the latter case the agreement was still close for separate water and steam zones, but the calculated heat transfer coefficient for the boiling zone was higher than according to measurements. Figures 5; references 17: 14 Russian, 3 Western (2 in Russian translation).

2415/12947
CSO: 1861/449

UDC 621.029.526

DISTRIBUTION OF RADIONUCLIDES OVER PIPE WALL THICKNESS IN PRIMARY LOOP OF BR-10 FAST REACTOR

Moscow ATOMNAYA ENERGIYA in Russian Vol 60, No 4, Apr 86 (manuscript received 16 Nov 84) pp 262-264

[Article by A. I. Lastov, Ye. A. Pavlinchuk, E. Ye. Konovalov, I. G. Sheynker, L. F. Lastova, I. A. Yefimov, and A. N. Mezentsev]

[Abstract] An experimental study was made in a nuclear power plant with a BR-10 fast breeder reactor using liquid sodium as coolant, for the purpose of determining the penetration of three principal radionuclides (^{137}Cs, ^{54}Mn, ^{60}Co) from corroded and broken shells of fuel elements through the liquid coolant into 12Cr18Ni10Ti stainless steel pipes of the primary loop during reactor operation. Ring specimens for radiometric analysis were cut from pipes of the discharge collector segment as well as from the large thermal compensator and the small thermal compensator. The distribution of those radionuclides over the thickness of a pipe wall was determined on the basis of activity measurements, after successive removal of 3-5 μm thick layers by electrochemical etching with an aqueous HNO_3 concentrate at a current density of 2.5-3.0 A/cm^2. The layer thickness was monitored by weighing before and after removal. The activity was measured with a Ge(Li) detector in a gamma-spectrometer. The experimental data have been processed so as to yield the diffusion coefficient and the concentration profile for each radionuclide. The results, after correlation with theoretical relations, indicate that during reactor operation all three radionuclides penetrate at least 100 μm deep into the pipe material. Figures 1; tables 2; references 8: 3 Russian, 5 Western (1 in Russian translation).

2415/12947
CSO: 1861/449

UDC 621.039.516.2

MEASUREMENT OF TEMPERATURE EFFECT ASSOCIATED WITH REACTIVITY OF URANIUM-WATER CORE ASSEMBLIES BY METHODS OF SUBSCRITICALITY MEASUREMENT

Moscow ATOMNAYA ENERGIYA in Russian Vol 60, No 4, Apr 86 (manuscript received 1 Feb 85) pp 264-267

[Article by V. I. Bagretsov, V. S. Bykovskiy, M. N. Lantsov, V. I. Lependin, O. I. Makarov, and V. I. Matveyenko]

[Abstract] Accurate and reliable prediction of the temperature effect associated with reactivity of a core assembly requires combining calculations with measurements, inasmuch as mathematical models alone either only approximately or even incorrectly describe the physical process which produces a temperature effect in intricate core assembly configurations. Measurements

near the critical state of a core assembly with movable compensators are difficult to interpret, because of the continuously varying assembly contents. Measurement by methods of subcriticality measurement is, therefore, proposed and its effectiveness is demonstrated on results of an experimental study made in the MATR-2 test stand at the Institute of Power Engineering Physics. Two methods were tried: neutron pulses and source knockout. The first method facilitates tracking changes in the core assembly on the basis of the damping factor of prompt-neutron concentration. The second method is based on the rate of decrease of delayed-neutron concentration in a core assembly after fast extraction of the neutron source from it. Measurements were made with reactimeters on a UO_2-H_2O core assembly of a VVER water-moderated water-cooled power reactor. Such a core assembly was tested at various constant temperatures up to 300°C. The fuel elements had been mounted into a hexagonal array 12.9 mm apart inside a hexahedral zirconium enclosure, fixed by upper and lower support plates and immersed in a water pool. The fuel assembly was or was not surrounded by a shield of cadmium and boron steel layers absorbing neutrons reflected by this water blanket. Calculations were made in the two-group diffusion and plane geometry approximation, using the applicable FACTOR and DNESTR computer programs. A comparison of the results reveals that the Simmons-King approximation used in these programs, although it yields good qualitative data, requires a correction for change in the neutron production time where neutron leakage is appreciable. Figures 1; tables 3; references 17: 14 Russian, 3 Western (1 in Russian translation).

2415/12947
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UDC 536.21:621.362

DETERMINING THERMAL INERTIA OF THERMOCOUPLE-CABLE TEMPERATURE TRANSDUCERS ON BASIS OF MEASUREMENTS BY PULSE METHOD

Moscow ATOMNAYA ENERGIYA in Russian Vol 60, No 4, Apr 86 (manuscript received 2 Jul 85, in final version 16 Sep 85) pp 293-294

[Article by Yu. V. Rybakov and A. A. Frolov]

[Abstract] Determination of the thermal inertia of thermocouples is necessary for accurate and reliable temperature measurement by these devices during fast processes in nuclear reactors, a thermocouple for this special application consisting of thermoelectrode alloy wires with sintered MgO-powder insulation inside a 12Cr18Ni10Ti steel sheath. Application of a radiation pulse to the thermocouple junction instead of conventional transfer from hot water to cold water is proposed, so as to eliminate both the unreliability and the inaccuracy caused by dependence of the thermal inertia index on the convective heat transfer coefficient and dependence of the latter on the speed of thermocouple immersion. Use of a radiation pulse offers the additional advantage of fast measurement with minimum heat loss. A procedure has been designed with a technological pulse laser, namely a "Kvant-10" welding laser, as radiation source. It has been calibrated oscillographically with Chromel-Alumel

thermocouples inside steel sheath 1.5 mm in diameter for the time of thermo-e.m.f. buildup to its maximum value after arrival of a laser pulse, against the theoretical relations for the thermo-e.m.f transient time $t_M = L^2/2\alpha$ (L- thickness of plate) in the case of a plane heat wave or $t_M = x^2/6\alpha$ (x-distance from heat-pulse point source to heat probe) in the case of a spherical heat wave (α - thermal diffusivity of plate or probe material). Figures 3; tables 1; references 9: 6 Russian, 3 Western (2 in Russian translation).

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CSO: 1861/449

UDC 621.039.526

MEASUREMENT OF MEAN CROSS-SECTION FOR ABSORPTION in ^{6}Li RELATIVE TO THAT FOR FISSION IN ^{235}U

Moscow ATOMNAYA ENERGIYA in Russian Vol 60, No 4, Apr 86 (manuscript received 8 Apr 85) pp 271-273

[Article by A. L. Kochetkov and Ye. A. Seregina]

[Abstract] An experiment was performed involving measurement of two mean cross-sections, A6 for neutron absorption in ^{6}Li and F25 for fission in ^{235}U. Measurements were made in BFS- and KBR-series critical assemblies with various neutron spectra. Absorption was measured with a ^{6}Li-counter consisting of a ^{6}LiF layer (denisty 30 $\mu g/cm^2$) between two n-Si crystals (electrical resistivity 300 ohm·cm) as surface-barrier detectors and a pair of preamplifiers inside a tubular probe, neutrons being produced by the ^{6}Li(n,α) ^{3}H reaction with Q= 4.78 Mev. Fission was measured with a layer of 90% enriched uranium density 50 $\mu g/cm^2$) containing ^{235}U and ^{238}U on a 0.05 mm thick aluminum foil substrate, sandwiched between two semiconductor counters. Extraction of the total signal from α -particles and tritium by means of an adder and a coincidence circuit appreciably attenuated the noise from protons produced by the Si(n,p) Al reaction on silicon. The ratio A6/F25 was calculated according to an expression relating this ratio to the ratio of pulse repetition rates in the reactor core and the thermal-neutron calibration column respectively, with a calibration factor including the ^{6}Li, ^{235}U cadmium ratio, a correction factor for presence of ^{238}U, and a correction factor for noncollinearity of the paths of α -particles and tritium scattering during neutron capture by a nucleus. Calibration against thermal neutrons was done in a graphite column. Figures 2; tables 1; references 9: 6 Russian, 3 Western.

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UDC 621.039.524:66.074:546.291

PURGING OF CO_2 FROM HELIUM COOLANT IN HIGH-TEMPERATURE GAS-COOLED REACTORS BY ADSORPTION METHOD

Moscow ATOMNAYA ENERGIYA in Russian Vol 60, No 4, Apr 86 (manuscript received 11 Feb 85) pp 246-248

[Article by A. V. Varezhkin, Ya. D. Zelvenskiy, I. V. Metlik, A. A. Khrulev, and A. N. Fedoseyenkov]

[Abstract] In order to ensure satisfactory performance of high-temperature helium-cooled reactors at 1100-1250 K, it is necessary to adequately purify the coolant and thus minimize its CO_2 content along with its H_2O vapor content so as to avoid chemical reaction with reactor core materials and their corrosion. Purging CO_2 by the adsorption method was studied experimentally with CaA zeolite as adsorbent, this material being produced at the Salavat Petrochemical Combine in granules of the 1.8-2.0 mm size fraction. An adsorber cell 16 mm in diameter containing a 310 mm high layer of this adsorbent was placed in the coolant stream and held stationary under dynamic flow conditions. Chemical analysis before and after adsorption was performed with a TBT (France) chromatograph, accurately within $\pm 5\%$. Tests were performed at temperatures of 273 K and $\geq$ 3 K, with the coolant velocity varied over the 0.02-0.055 m/s range and the coolant pressure varied over the 0.8-5 MPa range. On the basis of readings of the CO_2 concentration behind the adsorber cell were plotted "output" isoplans and adsorption isotherms. The data have been processed into empirical equations, the dynamic activity of the adsorbent having been calculated according to the Shilov equation with a $5 \cdot 10^{-5}$ vol.% CO_2 concentration behind the adsorber cell regarded as "excess." The results reveal an almost linear decrease of the CO_2 adsorption rate with increasing coolant velocity, coolant pressure, and temperature. It has also been established that CO_2 "excess" occurs much earlier than H_2O "excess" and, therefore, determines the safety margin of a power reactor under conditions of simultaneous CO_2 and H_2O purging. Further analysis indicates that separate drying and CO_2 puring is approximately 20% less economical but approximately 80% more energy efficient than combined helium purification. Figures 3; tables 1; references 7: 5 Russian, 2 Western.

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UDC 536.248.2

STEAM CONDENSATION IN LAYER OF UNDERHEATED STAGNANT LIQUID

Moscow ATOMNAYA ENERGIYA in Russian Vol 60, No 4, Apr 86 (manuscript received 13 Mar 85) pp 259-261

[Article by A. D. Kondratyev]

[Abstract] The performance of bubblers in nuclear power plants is examined, these devices being used for condensation of steam which has escaped through breaks in steam or hot-water pipes and thus localizing the consequences of a fault. Steam flows into a closed volume containing a layer of underheated stagnant water, whereupon condensation of the steam and bubbling of the water occur with an attendant buildup of the liquid layer by the amount of condensate. The process involves heat and mass transfer as well as phase transition in a system properly characterized by the Froude number. It is analyzed here, assuming a subsonic jet discharge of saturated steam from a single orifice into the bubbler chamber. Desired dynamic action begins and then continues as the increment of steam jet height Δh becomes equal to and then exceeds the increment of liquid layer thickness $\Delta 1$. For an evaluation of this criterion in the form of ratio $\Delta h/\Delta 1 \geq 1$ as a function of the degrees water underheat below vapor saturation temperature and as a function of the steam jet discharge velocity, both increments are expressed through respectively applicable thermophysical, hydromechanical, and geometrical parameters in accordance with theoretical and semiempirical relations. Figures 4; references 10: 8 Russian, 2 Western.

2415/12947
CSO: 1861/449

NON-NUCLEAR ENGINEERING

INCREASING EFFECTIVENESS OF THE USE OF TURBINES

Kiev ENERGETIKA I ELEKTRIFIKATSIYA in Russian No 2, Apr-Jun 86 pp 54-55

[Article by A. Vyshinskiy]

[Abstract] This article reviews the book "Povyshenie Effektivnosti Ispolzovaniya Turboustanovok" by A. A. Madoyan, L. N. Kodzarenko, V. V. Pashchenko, et al., Kiev, Tekhnika Press, 1984, 120 pages. The book will assist specialists in selecting the most effective operating modes for power generating units used to cover the peak portion of electric load schedules. The authors concentrate their attention primarily on increasing maneuverability (adaptibility to load changes) of 100-300 MW turbine sets to allow more effective use of these devices where electric loads vary sharply. Subjects discussed include characteristic operating conditions of power units with systematic regulation of electric load schedules; problems of the temperature status of turbine elements in the K-200-130 turbine under transient conditions; estimating and calculation of stresses and strains for operating cycles; problems of increasing maneuverability of turbines with various redundancy conditions; determination of economic expediency of using various methods of providing redundancy; and calculation of cost-benefit of redesign of thermal power plants.

6508/12947
CSO: 1861/499

UDC 621.18

INCREASING ECONOMIC EFFICIENCY OF 800 MW TURBINE SET

Kiev ENERGETIKA I ELEKTRIFIKATSIYA in Russian No 2, Apr-Jun 86 pp 7-8

[Article by V. S. Polivanyy, G. B. Rozenberg and V. F. Gorbunov, Engineers, Zaporozhye Regional Electric Power Plant]

[Abstract] The design of the 800 MW turbine set used at the Zaporozhye Electric Power Plant is described. Early operation of the systems revealed high resistance of the condensate drain pipes, which was reduced by rerouting the pipes, moving regulating valves and eliminating a slide valve. Further

improvement in the operation of the low pressure section is to be achieved by installation of a contact condenser on a line carrying a steam-air mixture. The present rate of air leakage into the vacuum system is 70-90 kg/hr, which is satisfactory for the needs of the user/manufacturing plant, but is 10-30 kg/hr more than allowable by the PTE [Rules of Technical Operation]. The rim seals of the high and middle pressure sections have been redesigned for all the turbines. These changes have reduced specific fuel consumption beneath the planned values, allowing it to approach the standards.

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UDC [621.311.25:621.039].004

TESTING MODERNIZED SYSTEM OF INTERMEDIATE STEAM SEPARATION IN MANIFOLDS OF K-500-60/1500 TURBINE

Moscow ELEKTRICHESKIYE STANTSII in Russian No 6, Jun 86 pp 13-15

[Article by D. G. Gostev, candidate of technical sciences, V. N. Grebennikov, candidate of technical sciences, Yu. L. Sorokin, candidate of technical sciences, and A. N. Khrunich, engineer, Podolsk Machine Manufacturing Plant imeni S. Ordzhonikidze and Central Institute of Boilers and Turbines]

[Abstract] Outlying vertical steam separator-superheater units are being installed in Soviet nuclear power plants for improving the reliability of wet-steam turbines. Industrial testing of a prototype separator-superheater under operating conditions is essential, since the high steam rates involved make laboratory testing prohibitive. Experience with intermediate steam separation and superheating in the Novovoronezh AES with VVER-1000 MW water-water power reactors and POAT turbines from the Kharkov Turbine Manufacturing Plant, also in power plants with VVER-440 MW water-water power reactors and RBMK-1000 MW graphite channel reactors, indicates that it is advisable to remove the water film from steam prior to entry into the separator. Subsequent tests were performed with separator-superheater units in manifolds for both medium-pressure and low-pressure cylinders of a K-500-60/1500 turbine, first with the turbine power changed stepwise over the 200-530 MW range after 20-30 min long operation at each power level and then with the turbine operating at the 420-435 MW power level but the temperature of the steam before the medium-pressure cylinder changed stepwise over the 240-193°C range by throttling the steam in the second separator-superheater stage. An evaluation of the experimental data reveals a very uneven load distribution between manifolds and between separator-superheater units, which can be equalized by installation of a film separator before a separator-superheater. Such intermediate separators are especially effective between the medium-pressure cylinder and the low-pressure cylinder, a film separator with an internal cone being most efficient. The quality of steam at the exit from the medium-pressure cylinder is 98.4% theoretically when the nominal steam temperature at the entrance to this cylinder is 245°C, but practically with an intermediate separator already when that temperature is 235°C. Therefore, lowering the

temperature of steam behind the separator-superheater to 235°C will ensure normal turbine performance under nominal conditions. Figures 4; references 5: all Russian.

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CSO: 1861/467

UDC [621.311.25:621.039].621.313.322.004.67

ORGANIZING OVERHAUL OF GENERATORS IN NUCLEAR ELECTRIC POWER PLANT

Moscow ELEKTRICHESKIYE STANTSII in Russian No 6, Jun 86 pp 15-18

[Article by I. A. Zelenyak, engineer, Leningrad Regional Administration of Power Equipment Overhaul]

[Abstract] Overhaul of generators in a nuclear electric power plant should be organized so as to minimize the shutdown time as well as the repair cost, also to improve the reliability of equipment and thus lengthen the mean time between ovehauls. This requires accounting for different reliability characteristics of the diverse equipment components until, some time in the future, all components can be made equally reliable. Periodic inspection, including dissassembly and reassembly, is an essential part of the overall organization. The inspection chart scipulates all inspection items in their proper sequence, lists all possible faults and the methods of detecting them, while the measurement chart is an inspection record listing the relevant equipment performance parameters with their readings before and after overhaul. Faults found during an inspection are classified into dangerous ones (requiring repair immediately, requiring repair during sooner than scheduled overhaul, requiring special countermeasures), faults of limited danger (requiring power cutback, causing higher losses, tolerable till next overhaul), and safe ones (normal wear, easily removable deviations, acceptable deviations). Implementation of procedures based on these concepts has, over a period of eight years, yielded positive results in terms more reliable equipment and more reliable inspection with fewer unaccounted for factors, lower cost of overhaul and repairs, and better labor management. Figures 2.

2415/12947
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UDC 621.183.371:621.182.08

MEASURING VIBRATION OF FEED PUMPS WITH PARALLEL ANALYZER

Moscow ELEKTRICHESKIYE STANTSII in Russian No 6, Jun 86 pp 39-40

[Article by V. I. Petrovich, candidate of technical sciences, G. V. Zusman, candidate of technical sciences, A. A. Nikulin, engineer, and V. A. Shpankin, engineer, All-Union Administration of Power Equipment Overhaul]

[Abstract] Extensive testing of feed pumps in the Moscow Regional Power System has revealed that their vibration covers a broad spectrum, with the velocity of harmonics and especially of the seventh usually much higher than that of the fundamental-frequency component. Typically high vibration velocity has been recorded in third and fourth bearings of PTN 110.0-350-24 feed pumps. Measurements were made by a team from the Central Mechanical Repairs Plant (Moscow Regional Administration of Power System Management), using a Schenk GmbH (FRG) "Vibroport" parallel-action vibration analyzer. Measurements were also made by a team from the Central Design Office (All-Union Administration of Power System Management), using a sequential-action vibration analyzer specially designed and built at that office. A comparison of the results revealed discrepancies between their spectral analyses, principally attributable to instability of individual vibration components with attendant seesawing. The parallel-action instrument was found to yield more accurate and reliable data. Such an instrument is therefore also being developed at the Central Design Office, for 20 frequency bands covering the 10 Hz — 10 kHz frequency range. The prototype, already built, consists of a piezoelectric vibration velocity transducer followed by an amplifier, an array of 20 approximately $\frac{1}{6}$-octave band filters in parallel, a multiplexer, a digital r.m.s. voltmeter, and a detector followed by a cathode-ray oscilloscope. Its error of spectral density measurement does not exceed $\pm 5\%$ within each band. It operates from a 220 ± 10 V a.c. power line and weighs 4 kg. Figures 1.

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UDC 621.313.322-82.016.313.001.2

RESULTS OF TESTING LARGE HYDROELECTRIC GENERATOR IN ASYMMETRIC OPERATING MODES

Moscow ELEKTRICHESKIYE STANTSII in Russian No 6, Jun 86 pp 43-48

[Article by S. S. Ananyants, candidate of technical sciences, V. T. Yurasov, engineer, B. M. Gindin, engineer, Yu. Ye. Lavrov, engineer, and L. I. Kuznetsova, engineer, All-Union Scientific Research Institute of Electrical Power Engineering and Scientific Research Institute of 'Elektrosila' (Electric Power) Leningrad Economic Planning Division]

[Abstract] A series of tests was performed on an SVF-1285.275-42 640 MW hydroelectric generator, these generators being the largest ones built in the USSR. Their principal features are direct water cooling of the stator winding, forced air cooling of the rotor, separate excitation through a thyristor bank, longitudinal-transverse damper cage with 10 bars/pole (two outermost bars in closed slots, remaining eight bars in semiclosed slots) and with shorting segments across interpolar space connected on each side through flexible two-strand jumpers. These are the first generators of this class assembled with clearance between stator core and yoke. Their rotor construction is analogous to that of CVF-1690/175-64 500 MW hydroelectric generators. The generator was tested in asymmetric operating modes, no such tests having been performed on these generators before. In the complete set of measurements were included heating of the damper cage and of the pole pieces, vibration of the stator winding and of the stator core, and currents in the damper cage. Temperature measurements were made with Cu-constantan thermocouples connected to a common Shch-1413 digital millivoltmeter and also each through an integrating galvanometer to an N-008 oscillograph. Vibration measurements were made with conventional transducers mounted at critical locations. The generator was tested in continuous 2-phase short-circuit with (0.08-0.1) I_{nom} negative-sequence currents as well as in symmetric steady-state operating modes, and in transient 2-phase short-circuit during kick excitation with (0.16-0.576)I_{nom} negative-sequence currents for durations of 55-458 s. An evaluation of the data, including juxtaposition of theoretical design data, indicates that the generator meets heating and vibration limits of GOST [State Standard] 5616-81 with a margin in continuous asymmetric operation with the difference between phase currents not exceeding 10%. Figures 3; tables 3; references 4: all Russian.

2415/12947
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UDC 621.313.322-82.043.2

VIBROACOUSTIC DIAGNOSIS INDICATING LOOSENED LAMINATIONS AT END OF STATOR CORE NEAR TEETH IN HYDROELECTRIC GENERATOR

Moscow ELEKTRICHESKIYE STANTSII in Russian No 6, Jun 86 pp 48-50

[Article by A. V. Shteynshneyder, engineer, All-Union Scientific Research Institute of Electrical Power Engineering]

[Abstract] Loosening of laminated stator teeth in an electric generator and their vibrations upon impact by the axial component of a magnetic field alternating at a frequency of 50 Hz are analyzed theoretically, such a tooth being regarded as a cantilever beam whose length depends on the amount of slack and whose natural frequency shifts from the linear range into the nonlinear range of the amplitude-frequency characteristic as the loosening of laminations extends deeper. This model, together with empirical relations derived from measurements after a reliability analysis of the data, has served as of a test designed for vibroacoustic diagnosis of tooth loosening in stator end stacks of hydroelectric generators, with the vibration acceleration as indicative parameter. The basic measuring unit consists of a DK12 or analogous piezoelectric accelerometer, a vibration-proof connecting cable, a matching preamplifier on a series K284UYe1A integrated-microcircuit chip, a band filter, and an independent r.m.s. noise meter. The number and the spacing of accelerometers on each end stack depend on the number of teeth and the tooth pitch, on the detection accuracy and reliability requirements, and on the signal attenuation. Measurements are made when the generator runs idle with nominal excitation and, for reference, without excitation. Such measurements made in the Dneper GES and in the Kapchagay GES over the 1982-85 period have established three criteria based on accelerometer readings for classifying the compression teeth in the stator end stacks as "good", "satisfactory", or "unsatisfactory". Figures 1; references 5: all Russian.

2415/12947
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UDC 536.27.533.6.013.43

STABILITY OF OPERATING CONDITIONS IN SHEATHED TUBULAR HEAT EXCHANGER CARRYING ONE-PHASE STREAM

Moscow TEPLOENERGETIKA in Russian No 7, Jul 86 pp 30-33

[Article by S. M. Kaplunov, candidate of technical sciences, Institute of Machine Science, USSR Academy of Sciences]

[Abstract] Stability of operating conditions in sheathed tubular heat exchanges carrying an either liquid or gaseous coolant is analyzed, considering vibrations with attendant wear at critical locations as the principal cause of fatigue failure. Excitation of vibrations by coolant flow and

hydroelastic scattering of energy by tube walls are included in calculations on the basis of dimensionless Navier-Stokes equations for fluids and equations of motion for solid, with applicable similitude criteria, as well as on empirical relations and experimental data. Numerical values for various bundling patterns with tubes made of various materials (steel, bronze, copper alloy, aluminum alloy, titanium alloy, acrylic) carrying either water or air provide an adequate base for roughly estimating the stability limit in such heat exchangers. Figures 3; tables 2; references 9: 3 Russian, 6 Western.

2415/12947
CSO: 1861/519

IMPLOSION DEVELOPMENT OF BOTTOM-HOLE FORMATION ZONES

Moscow NEFTYANIK in Russian No 1, Feb 86 pp 8-9

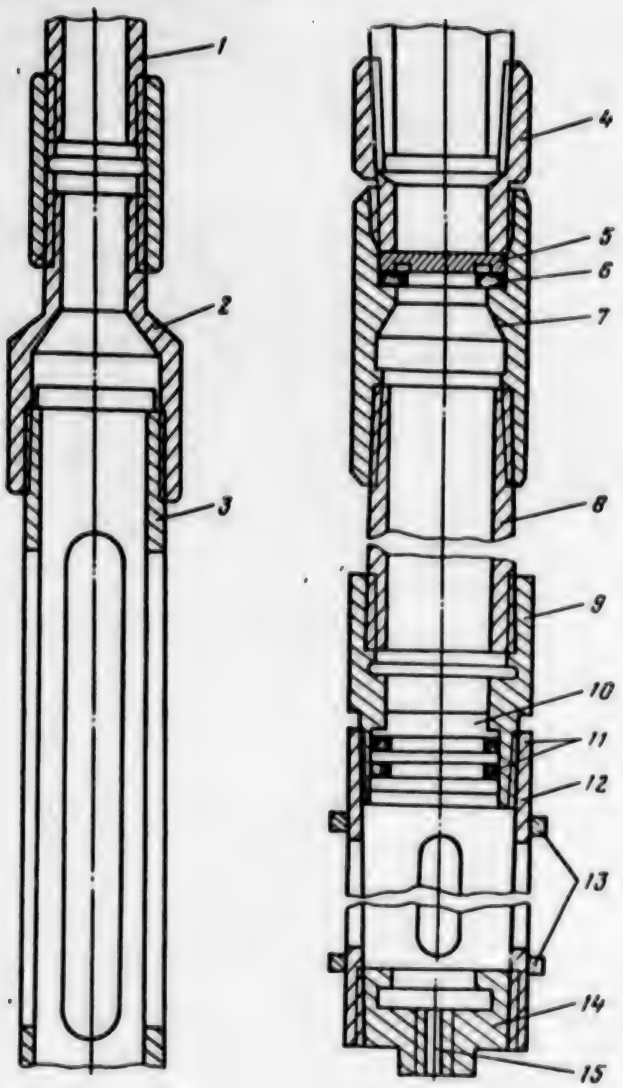
[Article by A. Popov, PechorNIPIneft: "Implosion: An Effective Method of Bottom-Hole Formation Zone Development"]

[Text] In the course of drilling and operating wells, artificial low-permeability barriers are formed on the surface of filtration channels due to flow reduction in the bottom-hole zones by silting, adsorption of asphalt-resin compounds and other processes, which leads to stagnation and pillars of retained oil. In this regard, not only is the productivity of the individual wells reduced, but so is the yield from the deposits as a whole. In order to reduce these negative phenomena, numerous different methods of working well bottom-hole zones have been developed. About 13,000 wells are treated annually at branch deposits, yielding more than two million tons of additional petroleum. However, in spite of the results achieved, the success rate of this work remains low for a number of reasons (branch-wide, it is 50 percent), and their effectiveness is unsatisfactory. Some types of treatment are not always available. Sometimes, the choice of method is made by oilfield workers not on the basis of the specific conditions at the deposit, but based on organizational opportunities, to wit, the method used in that particular region, its labor intensiveness, the complexity of the process, availability of equipment and technology, and so on. In this regard, some methods are underutilized and others are unproductive. Oilfield workers experience special difficulties in developing wells in northern deposits, which are characterized by poor reservoir features and significant productive-seam depths.

Under such conditions the implosion method is quite effective. The device used for it, called a hydraulic pressure generator (HPG) (Figure 1 [following page]) consists of a housing (8) (implosion chamber) within which there is a plunger (10) which acts as a dummy shutoff device, a membrane (5) clamped by a shoulder nipple (4), a guide pipe (3) with ports connecting the inside-pipe and outside-pipe spaces of the well with the chamber after the membrane breaks, and traps (12) with pressure concentrators (13). At slight pressure (ΔP=0.01 MPa), the plunger can separate from the housing and act as a check valve.

The device is lowered into the well on compressor-pump tubing so that the lower portion of it will stop level with the seam being worked. The outside-

Figure 1. Hydraulic Pressure Generator



Key:

1. NKT Tubing
2. Expander
3. Guide nipple
4. Shoulder nipple
5. Membrane-plug
6. Gasket
7. Special coupling
8. Housing (implosion chamber)
9. Reducing adapter
10. Plunger
11. Sealing ring [O-ring]
12. Trap
13. Pressure concentrators
14. Nut with safety ring
15. Opening for attaching crusher

pipe gate valves close, pumping the working agent (a water solution of PAV [surfactant], petroleum, hydrocarbon solvent or acid solution) into the well, the pressure at the wellhead is increased to 10-20 MPa, and the membrane is broken. After that, the fluid in the well quickly fills the implosion chamber and pushes the plunger out to the well bottom, to the trap, creating in the bottom-hole zone first a momentary depression and then a hydraulic shock at a pressure exceeding the overburden pressure.

The depression helps clean out the bottom-hole formation zone (BHZ) of particles of clay, paraffin and asphalt-resin sediments, and other contaminants, and the hydraulic shock provides conditions for widening natural or newly-formed residual fractures in the BHZ which, due to the irreversibility of the rock deformation processes, do not completely close under the pressure of the rock and are retained without pumping in stabilizing materials.

The basis of the method thus consists in improving the filtration characteristics of the BHZ and increasing the productivity of the well, achieved by using the energy of the hydraulic shock generated by a falling column of well fluid.

After the membrane is broken, which is determined by a sharp jump (drop) in pressure at the wellhead or by sound, the well is backwashed with a 1% water solution of ML-72 at 1.2 times the tubing capacity, the bed intake rate when the outside-pipe gate valves are closed is determined. Given an adequate bed intake rate (8 m^3/hr), initially a 15-percent hydrochloride solution and then a mud acid solution (up to 5-10 percent HF + 10-15 percent HCl) is pressed through it at petroleum and injection wells with compact, low-permeability terrigenous reservoirs or a hydrochloride (foam-acid) solution at wells with carbonate reservoirs. This solutions pumping sequence is to prevent the precipitation of poorly filtered insoluble calcium and magnesium fluoride sediments.

The residual acid in the tubing is pressed into the seam using a PAV water solution or petroleum. The well is then left alone for 1-2 hours so that the acid can react with the seam rock, after which the bottom-hole zone is cleaned of the reaction products by draining or by pumping additional petroleum or PAV water solution into the seam at a rate of 10 m^3 per 1 m of seam thickness.

If there is flow after treating an operating well, the generator is left in the well until the next subsurface maintenance and the well is put into operation without raising the HPG to the surface. After treating the bottom-hole zones of injection wells, given positive results, we begin pumping water, again without raising the generator to the surface.

In the absence of signs of flow, the tubing column and HPG are raised to the surface and the well is equipped for bottom-hole pumping.

The method possesses the following advantages:

thanks to the positioning of the membrane in the upper portion of the device and to the use of a nipple with ports, all the liquid in the well (in the tubing and in the space outside the pipe) participates in creating the hydraulic shock after the membrane breaks, intensifying the force of the shock;

thanks to the fact that a plunger which is easily separated from the generator housing by the descending flow of the working fluid is located in the

lower portion of the implosion chamber, conditions are ensured for the generation of a direct hydraulic shock in the seam zone being treated, facilitating the formation in the BHZ of a network of residual fractures without stabilizing them with sand, as is done in hydraulic formation fracturing;

the possibility is ensured of influencing the BHZ in a complex, multifactorial manner: pretreating with hydrocarbon solvents to dissolve paraffin-resin sediments, implosion to clean the bottom-hole zone of contaminants and to create fractures and then pump acid solutions or other intensifying agents into the seam. And all this is done without additional tubing column lowering and raising, simplifying treatment of the well;

after the well has been treated, it can immediately be put into operation without raising the generator to the surface;

thanks to the change in the length of the implosion chamber constructed with the tubing, given a specific orientation of it in the seam interval being treated, the device permits regulated differential-pressure stimulation;

thanks to the use of pressure concentrators in the trap, the device can be used for selective stimulation of the formation without using packer equipment;

the method is simple and technologically efficient. requiring only one Aznimash-30A pump and one lift, instead of the 5-8 4AN-700 units, sand-mixing unit and manifold unit required in hydraulic formation fracturing;

the method can be used at any deposits or wells, regardless of type of reservoir or depth and type of well.

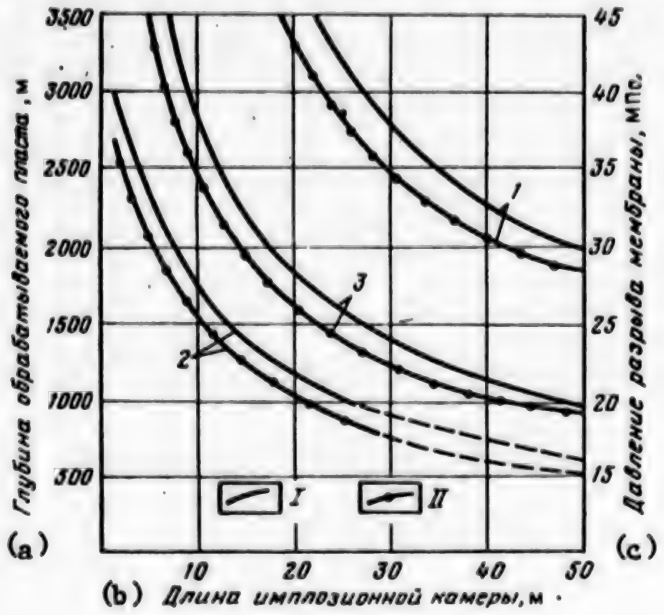
The targets most conducive to successful use of the process are wells in the initial stage of operation, which are characterized by high formation pressures but low productivity. The best results are achieved at low-productivity wells located in "acidified" zones of deposits or near high-productivity wells or wells with carbonate or fractured reservoirs, when the filtration surface and zone adjacent to the well are clogged during drilling, development or operation. The well preferably would have a sump 15-50 meters deep. Formation depth must not be less than two meters, with an injection rate of not more than 200 m^3/day.

It is proposed that hydraulic pressure generators be used first at wells where all other methods known and in use in that particular region have turned out to be ineffective, although the HPG can, in principle, be used to advantage at any low production-rate wells.

Before the generator is assembled, its threaded connections and rubbing surfaces need to be inspected, cleaned and lubricated. In every case, the implosion chamber must be pressure-tested for air-tightness to external pressure equal to the anticipated hydrostatic pressure. If a drop in fluid within the chamber is detected, individual subassemblies or parts must be replaced and the couplings and rubber gaskets must be tightened, since if fluids get into the generator chamber, there will be no implosion (the membrane will not break). The length of the implosion chamber should be chosen using the nomogram in Figure 2 [following page].

If a well is not filled with liquid, in order to prevent the plunger from dropping out as the tubing column is being pushed into position by the elevator, the generator must be lowered to the stationary level at a speed not exceeding 0.5 m/sec. It can then be lowered to the treated-formation interval at a speed of 1 m/sec.

Figure 2. Nomogram for Determining Generator Implosion Chamber Lengths which ensure creation in the formation zone being treated of a hydraulic shock with a pressure equal to one times (1), two times (2) and one and a half times (3) the overburden pressure when using the following as working fluids: I -- water, specific gravity 1,000 kg/m^3; II -- petroleum, specific gravity 855 kg/m^3



Key:

a. Depth of formation being treated, meters
b. Length of implosion chamber, meters
c. Pressure to rupture membrane, MPa

Experience in using HPGs to treat wells at deposits of the Komineft association has demonstrated its effectiveness. Thirteen of the 25 treatments were successful. The flow rates of several producing wells (Nos 193, 194 and 920) of the Usinskiy deposit, which is characterized by exceptionally low reservoir permeability $(50\text{-}100)\cdot10^{-15}$ m^2, were increased several-fold (from 1-6 to 32-77 tons/day). The injection rate of injection wells of the Usinskiy (No 795) and Vozeyskiy (No 604) deposits were increased from 170 to 480 and 130 to 430 m^3 per day, respectively. The duration of the effect was 6-24 months. The specific economic impact during 1984 was 23,200 rubles per well.

The hydraulic pressure generator has passed departmental acceptance testing and has been recommended by the Ministry of Petroleum Industry for introduction at at deposits of the branch. "Instructions on Treating Wells Using the GGD-89--350 Hydraulic Pressure Generator" (RD 39-1-1040-84) have gone into effect.

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RESULTS ARE SUPPLIED, AND TASKS ARE DETERMINED

Moscow STROITELSTVO TRUBOPROVODOV in Russian No 3, Mar 1986 p 2

[Text] Organizations and enterprises of the Minneftegazstroy made a weighty contribution in 1985 to the realization of the USSR's energy program. The results of their production-economic activity as well as the tasks for the first year of the new Five-Year Plan have been discussed at a comprehensive meeting of the collegium of the Ministry and the presidium of the Central Committee of the trade union of workers of the oil and gas industry. The deputy director of the heavy industry section of the Central Committee of the Communist Party of the Soviet Union, L. M. Kuznetsov, took part in the work of the collegium and presidium.

The minister of construction of enterprises of the oil and gas industry of the USSR, V. G. Chirskov, gave a lecture on results of work of the industry in 1985 and the tasks of the organizations and enterprises of the Ministry to fulfill the State plan of economic and social development during 1986. He noted that by having expanded the socialist competition for the worthy meeting of the 27th CPSU Congress, many collectives of the industry fulfilled ahead of schedule the specifications of the 11th Five-Year Plan for introduction of capacities and projects, the most important technico-economic indicators. The central construction projects of the Five-Year Plan were successfully completed. The CPSU Central Committee and the Council of Ministers of the USSR congratulated the builders, assemblers, and all participants in the creation of the six-line system of gas pipelines from Western Siberia to the European part of the country.

More than 14,000 km of main pipeline, 68 compressor and pumping stations, reservoir capacities for 760 thousand cubic meters, and cable and radio relay communication lines 3400 km in length have been put into operation in the concluding year of the 11th Five-Year Plan. Homes with a total living area of more than 1.9 million square meters, schools for 22.7 thousand students, preschool institutions for 12.9 thousand children, and other projects have also been completed.

Among the most important projects built for the petroleum industry--the Western Siberian pipeline--was the Uralo--Povolzhye leg with a length of about 1500 km. Fifteen new deposits in the Tyumen region have been placed under development. Nine installations for oil preparation, 52 precompression and

56 cluster pumping stations, 7 compressor stations, pipelines with a length greater than 7000 km, and a number of other buildings have been constructed in these industries.

More than 1300 km of the Yamburg--Yelets-I gas pipeline with two compressor stations went into operation for the gas industry ahead of schedule. Projects for the supply, preparation, and transport of gas to Urengoye, the capacities at the Mubarek gas reprocessing plant, and six gas refinery complexes gas have been put into operation.

A number of projects of primary state importance have been constructed for other sectors of industry. In all, commodity structural production of 5.72 billion rubles has been generated in 1985.

At the same time, as has been noted at the comprehensive meeting of the collegium of the Ministry and the presidium of the Central Committee of the trade union, the individual main directorates, associations, combines, enterprises, and organizations have not fulfilled the established tasks for putting into operation a number of production capacities and projects of social-domestic nature. Projects of a [social-domestic]-dedicated production base have not been satisfactorily constructed. The assignment for profit and growth of labor productivity has not been realized. Not all the industrial enterprises have fulfilled the plan of basic technico-economic indicators. The managers of a number of main directorates, associations, and combines have not adopted measures for the acceleration of introduction of new technique and technology for improvement of the organization of production and labor. Some subdivisions have not fulfilled the established tasks on economy of material-technical resources and have not improved their utilization of machines, mechanisms, and transport means.

The existing inadequacies and the possibilities for their elinination were analyzed at the comprehensive meeting of the collegium of the Ministry and the presidium of the Central Committee of the trade union.

The supervisors of central boards who spoke at the meeting, A. I. Nalivayko [Glavurengoygazstroy], M. O. Tulepov [Glavkazneftegazstroy], M. V. Chizhevskiy [Glavtyumenneftegazstroy], P. P. Shabanov [Glavsibtruboprovodstroy], A. S. Sorokin [Glavtatneftegazstroy], N. A. Zhukov [Glavyuzhtruboprovodstroy], Yu. P. Kudryashov [Glavukrneftegazstroy], L. V. Ilin [Glavneftegazmontazh], and also the general director of the "Sibkomplektmontazh" association V. A. Aronov, communicated about the state of matters in their own collectives and their plans for 1986. Secretary of the Central Committee of the trade union V. I. Bagayev discussed the development of socialist competition in the branch.

Socialist obligations of the branch's workers for 1986 were also discussed and approved.

In 1986 it is necessary for the collectives of Minneftegazstroy to fulfill construction-maintenance work of 0.5 billion rubles more than in 1985. Tasks associated with the development of the oil and gas industry of Western Siberia and the creation of the Prikaspiya oil and gas complex [near the Caspian Sea] should be accomplished.

In his concluding address V. G. Chirskov indicated the resources whose use will permit successfully accomplishing the program of oil and gas construction in 1986. These are first of all the acceleration of scientific-technical progress, improvement of the economic mechanism, further strengthening of discipline, organization, order, and improvement of work with the cadres.

The collegium of Minneftegazstroy and the presidium of the Central Committee of the trade union committed the managers and trade union committees of the main directorates, associations, combines, enterprises, and organizations of the Ministry and the republic, territory, oblast, city, and rayon committees of the trade union to adopt measures for maximum concentration of their efforts and resources on the start-up and most important construction projects without permitting deviations from the approved time-tables and tasks but providing for fulfillment of the encountered plans and socialist pledges by the collectives. It is necessary that the initiatives of the labor collectives of the "Sibkomplektmontazh" association and the Welding-Assembly combine, which have supported "avtovazovets" concept, obtain wide distribution in the industry. The attention of the competitors should be concentrated on intensification of construction output. The collegium of the Ministry and the presidium of the Central Committee of the labor union have approved the initiative of the Glavyamburgneftegazstroy and Glavsibtruboprovodstroy collectives concerning ahead-of-schedule preparation for start-up in 1986 of the compressor stations of the Yamburg--Yelets--II gas pipeline on the northern section of its route from the Nydinsk compressor station to the Komsomolsk compressor station.

Specific measures have been designated for acceleration of construction of the production capacities, especially in Western Siberia and Prikaspiya, as well as dwellings and projects of social-cultural and everyday purpose. A lot of attention should be devoted to the development of a dedicated or specialized industrial base.

It has been entrusted to the main technical directorate and the managers of the institutes and design bureaus to accelerate the readjustment of the structure of the industry scientific-research design and construction organizations and to intensify work on the creation and introduction into production of the newest achievements of science and technology and resource-conserving technologies.

The managers of the main directorates and associations are faced with the task of providing for the correct relationship between the growth rates of labor productivity and the average wage. Brigade forms of organization and stimulation of labor and the economic estimate in the brigades and complex technological production lines should receive further development. It is necessary to strengthen their role in raising labor productivity and the rational use of resources.

The collegium of Minneftegazstroy and the presidium of the Central Committee of the trade union have also decided to carry out measures for further improvement in the working and living conditions of industry workers.

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PEAT INSULATION FOR BUILDING IN WESTERN SIBERIA

Moscow STROITELSTVO TRUBOPROVODOV in Russian No 3, March 1986 p. 25

[Article by B. I. Stefurak and G. V. Fedorova, SibNIPIgazstroy, Tyumen and A. N. Reginbogin, Tyumentorf Association, Tyumen]

[Text] Sixty to 70 percent of the industrial structures of Western Siberia are insulated with keramsite, perlite, vermiculite, mineral wadding, plastic foam, and other heat-insulation material. At the Yamburg deposit alone, 150,000 m^3 of effective insulation is necessary for protection of permafrost soils. The high loading of the transport networks and the economic infeasibility of transporting light bulky loads point to a promising outlook for the production of heat-insulation materials based on a local raw material, for example, peat.

There are more than 1600 peat deposits in the Tyumen region. The predicted reserves of upper peat having a degree of expansion from 5 to 18% are sufficient for the fabrication of 200 million m^3 of heat-insulation materials.

No more than 1% of the total peat reserves have been investigated in the Western Siberian region. The peat resources of Khanty-Mansiysk and Yamalo--Nenetsk autonomous districts are practically unstudied.

The most promising deposit of low-expansion peat in the Tobolsk rayon is the Nerdinsk. The high quality of the peat of this desposit has been confirmed by the fabrication from it of an experimental batch of heat-insulation slabs. Peat of the highest quality has also come to light at the Pim--Trom--Yugansk deposit not far from Surgut. The search is continuing for peat in the Urengoy and Yamburg rayons.

The main requirement imposed on materials derived from an organic raw material is high bioresistance. One can obtain bioresistant peat heat-insulation materials through the introduction of antiseptics--salts of fluoride compounds.

The traditional technology for production of peat slabs is based on extraction of the intrinsic binders--materials of a bituminous nature--from the peat

through processing with hot steam. The water condensate which is formed increases the moisture content of the peat mass to 300%. 150--200 kg of water is removed during the pressing of 1 m^3 of peat slabs. The cost of the equipment for purifying the water of antiseptics exceeds the cost of the main production by a factor of two.

The introduction of an artificial binder--a clay suspension with admixtures of sodium silicon fluoride--offers the possibility of eliminating the formation of a condensate. In this case the moisture content of the initial peat clay mass does not exceed 75%. There is no liberation of water upon compaction of the material. The material obtained is bioresistant; however, its technico-economic data [R-factors] are lower than for others of this class of insulators.

A bioresistant heat-insulation material based on peat, liquid glass, and SFZh-3016 resol phenol-formaldehyde oligomer with a density of 450--500 kg/m^3 and a compressive strength of 0.35--0.5 MPa has been developed. It has proven possible to reduce the density of the material to 400 kg/m^3 and to raise its compressive strength to 0.6 MPa through the introduction of 6% distended perlite and 20% clay suspension.

In order to obtain such materials, milled peat with a moisture content of 70--90% treated in advance by hot steam is mixed with an antipyrene and an antiseptic in a forced-action mixer. Then a mixture of clay with resol phenol-formaldehyde resin mixed in advance for 5 minutes in a solvent agitator of the paddle type is introduced, and the entire mass is mixed for 10 minutes. After this, distended perlite is loaded into the mixer and mixed for another 7--12 minutes until a uniform mass is obtained. The mixture is poured into forms which are covered with solidol. The articles formed are subjected by means of rolling or pressing to drying at a temperature which provides for the complete removal of moisture while precluding the possibility of combustion.

During heat treatment of the heat-insulation mixture the water contained in the peat and clay causes the active elimination from the peat of humic acid, which facilitates hardening of the resin and clay. The solidified phenol formaldehyde resin prevents smoldering and burning of the material.

Peat granules, whose scientific production principles have been developed by the Moscow branch of VNIITP, is the material which is most promising and ready for introduction.

Peat raw material for production of granules is freed of stumps and other foreign inclusions in a key-actuated separator. Next the peat is fed by a scraper transporter into a supply bunker and through an auger to a disk granulator, in which it is sprayed with an aqueous solution of antiseptic (sodium silicon fluoride). The moisture content of the peat mass should be within the limits of 75--83%. The productivity of the granulator and the properties of the final product depend on the angle of inclination and the angular velocity of the disk.

The formation of nucleation granules starts in 5-7 minutes after the disk begins to turn. The damp peat granules slide through a chute onto a conveyor-dryer heated by hot air at a temperature of 110-200°C. The duration of granule drying is 30-50 minutes.

By varying the inclination angle of the disk one can regulate the diameter of the peat granules within the limits from 5 to 25 mm. The peat granules have a bulk density of 300-350 kg/m^3, a thermal conductivity coefficient of 0.068-0.072 W/(m·°C), a moisture absorption of 35-39% by mass in 24 hours, a moisture content of 5-7% by mass, and a strength of 0.30-0.32 MPa when compressed in a cylinder. The bioresistance of the peat granules has been confirmed by the results of investigations performed at the V. A. Kucherenko TsNIISK and the Tyumen Medical Institute.

Antisepticized peat granules can be used in place of keramsite for thermal insulation of roofs and as a filler in a mixture with perlite or vermiculite for walls and partitions of dwellings and production buildings.

In order to reduce the combustibility of peat granules, a method has been developed for treating them with liquid glass. Portland cement is used as the binder for the peat granules.

A new heat-insulating material has been developed on the basis of the granules and bitumen--bitumotorfinite--1 m^3 of which is cheaper by 5-10 rubles than bitumokeramsite for equivalent physico-mechanical properties. Bitumotorfinite can be used for thermal insulation of pipes. It is applied to the surface of the pipes similarly to itumokeramsite. Peat granules and perlite or vermiculite are mixed with heated bitumen and continuously pressed onto the pipe with the help of an auger. With the help of a press providing a pressure of 0.2 MPa one can fabricate slabs from this material. Such slabs and granules of peat plated into polyethylene packets can be used for the protection of permafrost soils.

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TRENDS, STATISTICS FOR COAL EXTRACTION TECHNOLOGY VIEWED

Kiev UGOL UKRAINY in Russian No 3 Mar 86 pp 22-24

[Article by A.Ye. Margulis, V.F. Kompanets, Candidates of technical sciences, Donugi, and Yu.P. Sidorov, Engineer, Ukrainian SSR Minugleprom]

[Text] **Development and implementation of effective means for repair and maintenance of development workings is one of important problems of technical progress of mines. The expenses of Ukrainian SSR Minugleprom mines for these items constitute approximately 15 % of total coal extraction expenses. 10-15 % of underground workers are busy repairing workings and haulage tracks. During this decade the labor content of these jobs has stayed practically at the same level, which in 1984 was 610 man-shifts per 1 km of maintained workings, or 53 man-shifts per 1,000 tons of coal.**

Cutting or trimming of rock which is prone to heaving is a very labor consuming a practically unmechanized type of repair. The overwhelming majority of operating mines in the Ukraine have heaving rock. The annual scope of this type of repair, even taking into account the complex of measures on repairless maintenance of the workings that is being implemented, has a tendency to grow, due to the steadfast increase of development depth and overall length of maintained workings.

In 1968, the overall length of cutting at the Donbas mines was 1997 km, or 61.5% of the total volume of cutting in the USSR coal mining industry. Practically all the cutting was performed manually or with jack hammers [1]. Regarding this basin as characteristic of the industry as a whole, as far as mining and geological conditions and methods for mechanization of soil cutting are concerned, Donugi and Technical administration, Ukrainian SSR Minugleprom, analyzed volumes and conditions of and methods for soil cutting in the Ukraine mines. The goal of the study was to determine required types of soil cutting machines, efficient lay-out of main functional assemblies and possible applications thereof. 94.6% of mines had been inspected (with the exception of mines of Ordzhonikidzeugol and Aleksandriyaugol conglomerates). 221 mines have heaving rock. In 1984, 4,552 km of workings were repaired (31.4% of overall length of maintained workings), including 2,345 km with soil cutting*.

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* Candidate of technical sciences I. T. Manzhula (Donugi) participated in the preparation of the article.

The distribution of volumes of cutting among the Ukrainian SSR Minugleprom conglomerates is presented in Table 1. The highest volume of cutting was performed at the following conglomerates: Donetskugol- 503 km (21.4 % of the overall volume) and Selidovugol- 185 km (7.9 %). All in all, out of 22 inspected conglomerates, the volume of cutting at 9 of them is over 100 km, and at 7 others it is over 50 km.

Table 1

(1) Объединения	Кол-во обследованных шахт	Отремонтировано выработок в 1984 г., км		Распределение объема поддирки, %						
		(27) всего	(28) с поддиркой почвы	(30) по типу транспорта: (31) рельсовый	(32) комбинированный	(33) конвейерный	(34) прочие	(35) по глубине поддирки: <0,5 м	0,5–1 м	>1 м
(2) Донецкуголь	20	1012	503	51,1/13,2	19,0	14,3	2,4	37,5	49,0	13,5
(3) Макеевуголь	7	127	73	52,5/15,0	22,0	9,0	1,5	42,8	41,6	15,6
(4) Советскуголь	11	196	66	65,3/10,3	7,0	17,3	0,1	27,3	68,0	4,7
(5) Красноармейскуголь	6	235	172	39,4/16,8	15,3	24,6	3,9	61,5	32,9	5,6
(6) Селидовуголь	7	280	185	52,2/5,8	5,6	35,4	1,0	40,0	53,7	6,3
(7) Добропольеуголь	7	216	139	65,6/2,9	12,8	13,8	4,9	27,2	62,2	10,6
(8) Артемуголь	9	230	123	95,4/4,6	—	—	—	51,9	48,1	—
(9) Дзержинскуголь	7	137	71	87,1/12,9	—	—	—	79,6	19,8	0,6
(10) Шахтерскантрацит	10	170	93	74,0/19,3	0,5	6,2	—	29,2	67,8	3,0
(11) Октябрьуголь	9	106	25	74,7/20,1	—	5,2	—	39,0	61,0	—
(12) Торезантрацит	17	142	54	64,9/21,0	0,9	9,3	3,9	32,0	65,2	2,8
(13) Ворошиловградуголь	14	235	85	49,4/23,8	15,4	11,4	—	58,0	33,8	8,2
(14) Стахановуголь	17	317	116	56,5/14,0	7,9	21,6	—	46,9	48,8	4,2
(15) Краснодонуголь	12	67	47	39,5/18,0	19,8	19,7	3,0	42,2	55,9	1,9
(16) Лисичанскуголь	7	174	152	38,9/21,6	16,9	20,2	2,4	50,2	38,7	11,1
(17) Донбассантрацит	11	77	29	50,9/48,4	0,7	—	—	38,2	61,8	—
(18) Первомайскуголь	8	124	90	58,7/23,3	0,7	17,3	—	36,0	50,6	13,4
(19) Антрацит	7	45	20	25,3/64,6	10,1	—	—	39,9	60,1	—
(20) Свердловантрацит	12	54	34	27,6/27,2	32,0	11,5	1,7	22,9	57,1	20,0
(21) Ровенькиантрацит	7	254	21	50,6/32,3	14,7	2,4	—	50,2	49,3	0,5
(22) Павлоградуголь	11	191	146	64,3/4,9	3,9	22,3	4,6	35,2	51,6	13,2
(23) Укрзападуголь	16	165	101	50,3/20,2	21,3	7,9	0,3	41,2	58,5	0,3
(24) Минуглепром УССР	232	4552	2345	56,6/14,3	11,8	15,4	1,9	42,3	49,5	8,2

Note. The numerator shows data for single-track workings, and the denominator shows data for two-track workings.

KEY:

1. Conglomerates
2. Donetskugol
3. Makeyevugol
4. Sovyetskugol
5. Krasnoarmeyskugol
6. Selidovugol
7. Dobropolyeugol
8. Artyomugol

(Key continued on following page)

9. Dzerzhinskugol
10. Shakhtyorskantratsit
11. Oktyabrugol
12. Torezantratsit
13. Voroshilovgradugol
14. Stakhanovugol
15. Krasnodonugol
16. Lisichanskugol
17. Donbassantratsit
18. Pervomayskugol
19. Antratsit
20. Sverdlovantratsit
21. Rovenkiantratsit
22. Pavlogradugol
23. Ukrzapadugol
24. Ukrainian SSR Minugleprom
25. Number of mines inspected
26. Length of workings repaired in 1984, km
27. Total
28. With soil cutting
29. Distribution of volume of cutting
30. According to the type of transportation
31. Rail
32. Combination
33. Conveyor
34. Other
35. According to the depth of cutting

At the Ukrainian SSR Minugleprom, the average volume of cutting per mine is 10.1 km. At Donetskugol, Krasnoarmeyskugol and Selidovugol conglomerates this index exceeds 25 km, at Lisichanskugol and Dobropolyeugol it is about 20 km, and in conglomerates with anthracite beds developing mines it does not exceed 2.5-3 km. At 54 mines (24.4 %) the length of cutting does not exceed 3 km, at 92 mines (41.6 %) it is from 3 to 10 km, and only at 14 mines (6.3 %) it is over 30 km. The maximum annual volume was recorded at mine administration imeni "Sotsialisticheskiy Donbass" newspaper (Donetskugol): 98.3 km.

The hardness factor of heaved rock varies from 1 to 10, with 89.6 % being rocks with hardness 3-6. Considerable volume of cutting of rocks with hardness of 5-6 is due to gradual shifting of mining to deeper strata.

An important factor that is directly affecting the tecnological maintenance schedule, equipment lay-out and productivity, is the depth of cutting. Thus, the depth of 91.8 % of cutting did not exceed 1 m, whereas roughly half of it was less than 0.5 m. Trimming more than 1.5 m indicates untimely performance of repair work and not keeping safe gaps for operating typical cross-sections. It has been established that the main volume of cutting, 70.9% is performed in workings equipped with rail transport, including 56.6 % in single-track workings. 15.4 % are in workings with conveyor transport and 11.8 % are in workings with various combinations of rail and conveyor transport.

Table 2

(1) Объединения	(13) Протяженность подсечки, км	Объем поддирки почвы, % (14)				
		(15) серийным проходческим оборудованием	(16) почвоподдирочными машинами	(17) БВР с ручной погрузкой	(18) отбойными молотками	(19) вручную
(2) Донецкуголь	503	7,6	4,7	11,3	48,5	27,9
(4) Селидовуголь (3)	185	0,5	—	42,2	—	57,3
(6) Красноармейскуголь (5)	172	0,9	0,9	23,6	0,1	74,5
(8) Лисичанскуголь (7)	152	1,2	2,6	55,3	—	40,9
Павлоградуголь	146	8,4	0,8	5,6	—	85,2
Добропольеуголь (9)	139	5,0	1,2	28,3	—	65,5
Артемуголь	123	1,9	—	—	11,5	86,6
(10) Стахановуголь	116	—	1,0	21,9	—	77,1
(11) Укрзападуголь	101	5,4	0,4	18,4	—	75,8
Прочие объединения	708	3,2	3,1	21,8	4,6	67,3
(12) Минуглепром УССР	2345	3,9	2,4	21,6	12,4	59,7

KEY:

1. Conglomerates
2. Donetskugol
3. Selidovugol
4. Krasnoarmeyskugol
5. Lisichanskugol
6. Pavlogradugol
7. Dobropolyeugol
8. Artyomugol
9. Stakhanovugol
10. Ukrzapadugol
11. Other conglomerates
12. Ukrainian SSR Minugleprom
13. Length of cutting, km
14. Volume of cutting, %
15. Using standard cutting equipment
16. Using soil cutting machines
17. Using ED [explosion drilling] with manual loading
18. Using jack hammers
19. Manually

Table 2 presents the distribution of volumes of cutting at Ukrainian SSR Minugleprom mines in 1984 according to means for mechanization (conglomerates with the volume of cutting over 100 km were selected as an example). At all conglomerates manual labor is prevailing in this operation, with its productivity usually not exceeding 1.5-2 m^3 per man-shift. Within the Ukrainian SSR Minugleprom, 93.7 % of all cutting work is performed either manually or using explosion drilling or jack hammers with subsequent manual loading of the broken rock mass.

There is experience in using for cutting traditional cutting equipment, such as 4PU, PK-3, GPKS and 4PP-2 road headers and 1PNB-2 loading machines (3.9%). However, to use the latter, it is necessary, as a rule, to first loosen the rock mass. Standard road headers are used for cutting in isolated instances, due to the high metal content and power requirements for these machines. The share of specialized cutting machines is 2.4% of the total volume of cutting.

During the last decade, IGD imeni Skochinskiy, TsNIIpodzemmash, Donugi, Pechorniiproekt, KNIUI, Karaganda Polytechnic Institute, VNIIOMShS and PNIUI have performed a complex of research and development work. Machines that vary as to the method of attacking the heaved rock mass and design lay-out of principal functional assemblies, as well as the method of performing the cutting, have been developed and undergone experimental operation. But none of these developments have been completed, due to their technical and operational flaws, scarcity of production facilities, lack of necessary perseverance and interest on the part of enterprises involved in the design, manufacturing and operation of this type of mining equipment.

Using imported trimming or cutting machines [2] in mines made it possible to increase productivity by the factor of 2-2.5, on the average, and reduce the labor content of the work. However, it is not advisable to count on importing expensive but, designwise, simple equipment, because just for the Ukraine coal mining industry the demand is 550-600 machines. According to existing volumes and conditions of cutting, it is advisable to have several types of cutting machines. One type is machines based on a compact selective action road header of modified design and with different tool parameters. The advantages of these road headers, such as their low mass, compactness, high maneuverability, capability to operate in workings of various shapes and cross-sections and overlapping of breaking and loading operations, are of utmost importance under cramped repair conditions, whereas the capability of rear unloading makes these machines applicable in practically all types of workings. Their application field are single-track workings, as well as two-track workings with soil hardness of 4-6. The share of these machines in the overall fleet should be about 40 %.

Another variety are machines based on a selective action road header equipped with a composite, impact-cutting tool. After appropriate changes and coordination (first of all from the overall dimensions standpoint) of principal functional assemblies, such machines can have an application niche (5-10 %) in cutting of hard rock, particularly in anthracite mines, and, in some cases, when combining cutting with roof dressing. As a base for installation of a manipulator with a hydraulic hammer, 1 PNB2 or MPK-3 loading machines can be used. The experience in operating imported bucket-type soil trimming or cutting machines with front or side (57°) unloading demonstrates that they operate most efficiently in two-track workings, as well as in single-track ones, if it is possible to put a hauling unit (a shuttle car, a conveyor, a container) side-by-side with the machine. Otherwise the productivity of cutting decreases due to the need for carriage maneuvering. Mounting of a holder with hydraulic hammers under the lower edge of the bucket (active bucket)

makes it possible to effectively hew rocks with the hardness factor of up to 4. The industry demand for such machines is approximately 250 pieces (40-45 % of the required fleet). It should be noted, that in the case of cutting fracturing rock with hardness up to 3, there is no need in activization of the bucket tool, as breaking of the bloated rock mass can be done by power crowding created by the machine carriage. This simplifies the design of the machine, and at the first stage can facilitate the speedest organization of series production of bucket machines. Possible scope of application is 80-100 machines.

A number of basic flaws of machines with the rail drive (effective breaking of rocks with hardness over 2, as well as of soft clay rock disposed to sticking, is impeded; soil profile of repaired sections does not conform to the design profile, due to non-uniform heaving over the length and the width of the working; the web front size and depth of cutting are not adjustable; high level of manual clearing of soil; considerable labor content of installation and dismantling) do not allow to view this direction as progressive. However, there is a certain field of application for these machines (5-7 %), first and foremost for track repair. In this area, the experience of mines researchers, who successfully developed such machines using cleaning equipment that had been written off, like "Donbass-1G" and "Kirovets" coal cutting machines, can be used.

As practical experience demonstrates, machines for combined application, like K-1000 and "Shtrek", with changeable tools for various types of repair dealing with cutting, do not provide high productivity due to low bucket capacity and power crowding.

The coal mining industry has accumulated certain experience in mechanized cutting. It is necessary to get a number of scientific and research and design and development organizations and manufacturing plants involved in performing a complex work aimed at the speedest development of highly efficient domestic cutting machines. It is our opinion, that objective conditions exist for starting series production of this type of equipment in the 12th 5-year plan period.

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BRIEFS

NEW FAMILY OF STRIPPING EXCAVATORS--"Novokramatorskiy Mashinostroitelnyy Zavod" Association is developing a family of powerful stripping excavators. Excavator "ESh-11/70" is going to be the first in the family. It will be able to process 3.2 million cubic meters of rock annually. An industrial lot of these giants, that have an 11 cubic meters bucket and a 70 meters long boom, will be manufactured as quickly as next year. Excavator "ESh-15/80" will be the second. Its very name indicates, that it will have a 15 cubic meters bucket and an 80 meters long boom. And in 1990 the Association will build a 20 cubic meters excavator. [Text] [By N. Lisovenko, "Izvestiya"'s own correspondent] [Moscow IZVESTIYA in Russian 10 Apr 86 p 1] 12770/12947

ANALYSIS OF EFFECTIVENESS OF USING REGULATED ELECTRIC DRIVE OF FEED PUMPS FOR 200-MW POWER-GENERATING UNIT OF TES

Kishinev IZVESTIYA AKADEMII NAUK MOLDAVSKOY SSR: SERIYA FIZIKO-TEKHNICHESKIKH I MATEMATICHESKIKH NAUK in Russian No 1, Jan-Apr 86 (manuscript received 14 Jun 84) pp 37-43

[Article by A. D. Korninenko, B. B. Petrov, Ye. P. Prusakova, V. M. Cherepanin and Ye. M. Yaroshenko]

[Text] The mechanisms for internal needs at modern TES [thermoelectric power plant], the main ones of which are the feed and condensate pumps, flues and blowers, are equipped with unregulated electric drive based on asynchronous motors with short-circuited rotor.

Their performance is regulated by orificing the working medium, by varying the number of operating machines and by using two-speed motors. This regulation is uneconomical and causes considerable losses of electric power and fuel, especially discernible during operation of power-generating units during peak or semipeak conditions. Losses due to orificing also occur in basic operating modes of the electric power plant, since the performance of mechanisms for internal needs is selected according to conditions of the reliability of power-generating units for a given operating mode with some reserve [1, 2].

The use of a thyristor electric drive to regulate the mechanisms for internal needs--essentially one of the main methods of increasing their efficiency and operating reliability--is a method, capable of providing considerable conservation of fuel and electric power under conditions when the requirements on increasing the efficiency of energy production and on reducing the specific fuel and electric energy expenses are determining factors at the modern phase of development of power engineering.

Replacing the control system with guide apparatus and regulating valves with an AC thyristor electric drive requires specific capital expenditures. In the first approximation, an estimate of the efficiency of using a regulated electric drive can be given, as shown in [3], by consolidated indicators that take into account only the difference in the relative losses of electric power upon regulation of the rotational frequency of the mechanisms for internal needs and by orifice regulation. However, this calculation does not take into account the characteristic features of the circuit the operating modes and other factors related to the use of one or another mechanism.

The role of the feed pumps, is as important as that of the primary thermo-mechanical equipment (boilers and turbines) in modern electric power-generating units; they are entrusted with the job of boiler feed regulation [1,4], which is especially crucial in the production cycle of electric power generation. The feed pumps are the most power-hungary mechanisms for internal needs. This permits one to expect the greatest saving due to regulation of their performance, especially under adjustable operating conditions. Analysis of the effectiveness of using a thyristor electric drive for electric feed pumps (PEN) of these power-generating units with regard to the characteristic features of the boiler feed circuit and operating modes is of considerable interest with regard to the increasing use of 200-MW power-generating units of thermoelectric power plants to the load schedule regulation modes of energy systems.

As is known [1, 4], a boosterless boiler feed scheme with two feed pumps of 100 percent load or three feed pumps of 50 percent load (two main and one standby) has become widespread at electric power plants for 200-MW power-generating units. The latter determines both the characteristic features of using a thyristor electric drive for electric feed pumps and the characteristic features of the method of analyzing its economic effectiveness.

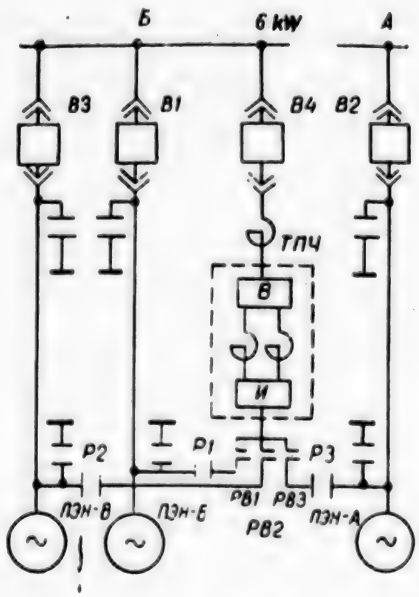

Figure 1. Diagram for Connection of Frequency Converter to Three Feed Pumps

Feed pumps of type PE-380-185/200 and asynchronous short-circuited motors of type 2AZM-3200/6000 are usually employed for the case of boiler feed under consideration. The most efficient electric drive system is the "thyristor frequency converter-asynchronous short-circuited motor" system. A diagram for connection of a high-voltage frequency converter to any of the three electric feed pumps of a 200-MW power-generating unit is shown in Figure 1. Since each of the three electric feed pumps is designed for approximately 50 percent load,

this diagram permits one to provide frequency start of any of the three electric feed pumps and regulation of its performance to a rated value, corresponding to incomplete load of the power-generating unit. Thus, for example, the load of the power-generating unit of 150-160 MW corresponds to the rated performance of the PE-380-185/200 pump (10 stages, D = 395 mm) of 420-440 t/hr at consumption characteristic of the power-generating unit of 200 MW (Figure 2). In this case, the electric feed pump is switched to power supply from the main system. The required consumption of feed water of 590-600 t/hr (see Figure 2) is provided by connection and regulation using the frequency converters of the second electric feed pump upon a further increase of the load of the power-generating unit to the rated value.

The effectiveness of using a regulated electric drive for the considered boiler feed circuit is estimated by the difference of outputs, consumed from the main system by one and two electric feed pumps operating in parallel, with orifice regulation of the performance of PE-380-185/200 pumps and with regulation of their rotational frequency.

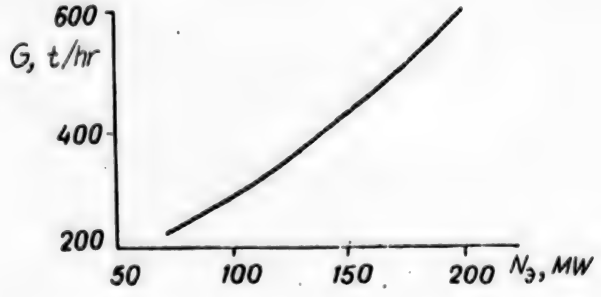

Figure 2. Consumption Characteristics of 200-MW Unit

The characteristics H = f(G) for one and two pumps of type PE-380-185/200, operating in parallel at constant rotational frequency, are presented in Figure 3. As can be seen from Figure 3, the total delivery (performance) of pumps operating in parallel with the feed valve on the delivery line completely open exceeds the required working delivery in the nominal mode at load of the power-generating unit of $N_э$ = 200 MW (point 4). A decrease of delivery is provided by simultaneous orificing of both pumps through an artificial increase of resistance Δh_3 on the number line (by throttling the feed valve).

Construction of the characteristic of the pump H = f(G) upon orificing and with total operating characteristic achieved by adding the corresponding characteristics of two pumps operating in parallel, is shown in Figure 3 by the dashed curve. The consumed power with this regulation by one and two pump units operating in parallel is determined by the well-known relation:

$$P = \frac{\gamma \cdot Q \cdot H}{102 \cdot \gamma \cdot \eta_н \cdot \eta_{дв}} \text{ kW}, \qquad (1)$$

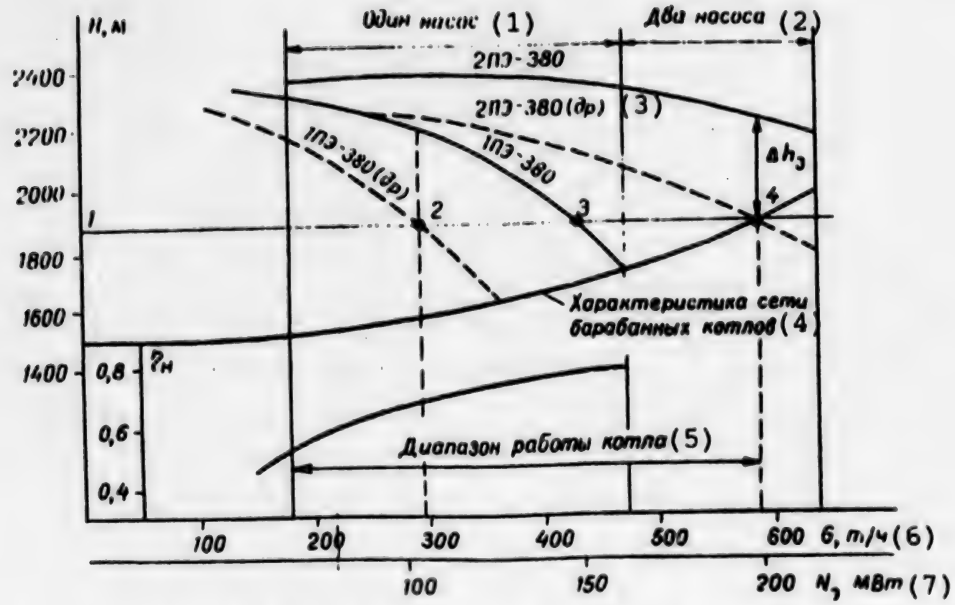

Figure 3. Operating Modes of Electric Feed Pump in 200-MW Unit With Drum Boiler at Constant rpm

KEY:

1. One pump
2. Two pumps
3. Orificing
4. Characteristic of drum boiler system
5. Range of boiler operation
6. t/hr
7. MW

where H is the pump delivery, m, γ is the specific weight of the feed water (γ = 915 kg/m^3) and η_H and $\eta_{ДВ}$ are the efficiency of the pump and of the asynchronous motor, respectively. One must take into account in the calculation that the efficiency of the pump during orificing is reduced:

$$\eta_н = \eta_н \cdot \frac{H_c}{H} \qquad (2)$$

(H_C is the pressure head corresponding to given delivery).

In relation (2)

$$H = H_c + \Delta h_э. \qquad (3)$$

The dependence of the efficiency of the asynchronous motor upon variation of its load $\eta_{ДВ} = f(p_{*\ пол})$ is presented in Figure 4. The characteristic was found on the following assumption [5].

Let us assume that the optimal mode of the asynchronous motor corresponds to the rated mode, i.e., $\eta_{дв.\ опт} = \eta_{дв.\ ном.}$ The losses in the unregulated asynchronous motor consist of the constants (K) and variables (V) proportional to approximately

the square of the load $V = BP^2_{*\ пол}$ where the relative value of available power on the motor shaft is $P_{*\ пол} = P\ P_{ном}$.

(Translator's note: Page 40 of original text is missing.)

$$G_x = G\frac{n_x}{n};\quad H_x = H\left(\frac{n_x}{n}\right)^2;\quad P_x = P\left(\frac{n_x}{n}\right)^3. \tag{6}$$

where G_x, H_x and P_x are the enumerated parameters of the pump, n is the rotational frequency of the pump and n_x is the rotational frequency of pump at point G_x.

The dependence of the power consumed from the system by one and two PE-380-185/200 pumps, operating in parallel with the rotational frequency of one pump being regulated, is shown in Figure 5 (functions 2 and 2'). When determining the power, one must take into account the efficiency of the electric drive to be regulated:

$$\eta_{парна} = \eta_{дв} \cdot \eta_{преобр}, \tag{7}$$

where $\eta_{преобр}$ is the efficiency of the frequency converter.

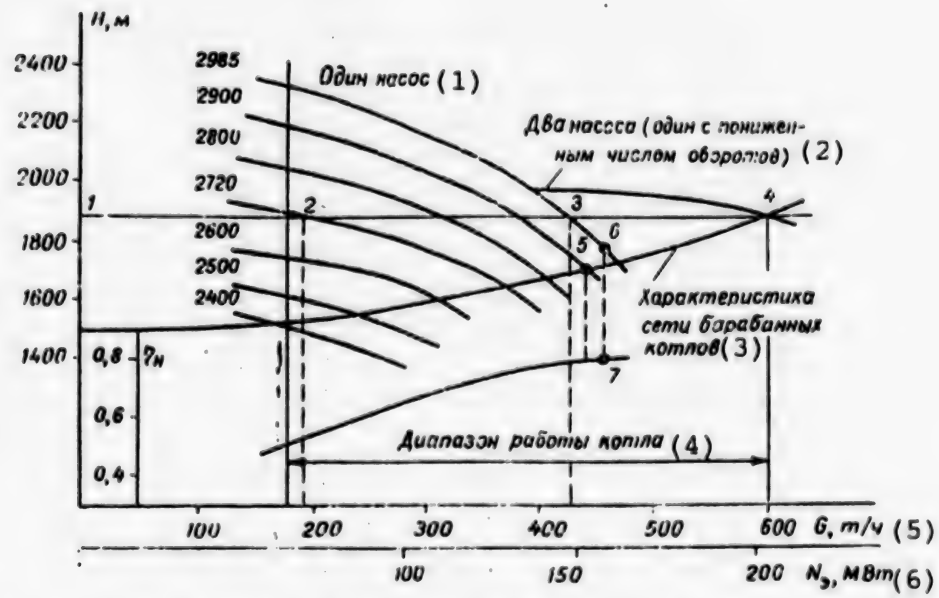

Figure 6. Operating Modes of Electric Feed Pump in 200-MW Power-Generating Unit With Drum Boiler and With Regulation of Number of Revolutions

KEY:

1. One pump
2. Two pumps (one with reduced revolutions)
3. Characteristic of network of drum boilers
4. Operating range of boiler
5. t/hr
6. MW

The standard function $\eta_{прив}=f(n\ n_{ном})$, corresponding to the optimal frequency control, is shown in Figure 7 [6]. The given function was found for an electric drive with SPChR-3500/6 thyristor converter [7] and with 2AZM-3200/6000 asynchronous motor. It is obvious that the efficiency of this electric drive in the rotational frequency regulation range of (0.6-1) $n/n_{НОМ}$ remains approximately identical and equal to 0.9-0.91.

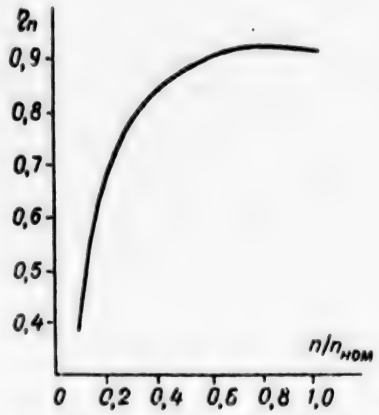

Figure 7. Dependence of Efficiency of Drive With SPChR-3500/6 Frequency Converter on Rotational Frequency

Since the power consumption by the pumps in Figure 5 is linked to the load of the power-generating unit, by knowing the length of operation of the latter under different loads, we can determine the annual conservation of electric power on the basis of conservation of the power consumed by the pumps. Let us consider as an example a typical annual load schedule of the 200-MW power-generating unit of the Moldavia GRES. The power generating unit carries a load of 200 MW for t_1 = 4,456 hr, 140 MW for t_2 = 2,249 hr and 80 MW for t_3 = 900 hr at total length of the annual run of $t_г$ = 7,605 hr. Accordingly, we determined the conservation of consumed power upon rotational frequency regulation of the pump of ΔP_{200} = 620 kW, ΔP_{140} = 400 kW and ΔP_{80} = 600 kW by these loads of the power-generating unit according to the unit of the function presented in Figure 5. The annual conservation of electric power for internal needs thus comprises:

$$\Delta Э_{сн}=\Delta P_{200}\cdot t_1+\Delta P_{140}\cdot t_2+\Delta P_{80}\cdot t_3. \qquad (8)$$

With regard to the values $\Delta Э_{сн}=4202320$ kW·hr. Assuming that the consumption of electric power for internal needs comprises ~6 percent of the power generated by the 200-MW unit annually, we find:

$$Э_{сн}=0{,}06\cdot Э=0{,}06\cdot N_{э.ном}\cdot t_г. \qquad (9)$$

After substitution of values

$$Э_{сн}=0{,}06\cdot 200\cdot 10^3\cdot 7605=91{,}26\cdot 10^6 \text{ kW·hr}.$$

The annual conservation of electric power for the internal needs of the 200-MW power-generating unit when using a regulated PEN electric drive, with regard to (8) and (9), comprises:

$$\Delta Э^{*}_{сн} = \frac{\Delta Э_{сн}}{Э_{сн}} \cdot 100 = 4{,}6\%.$$

If one assumes unit fuel consumption equal to the average normative value of m = 328 g/(kW·hr) [8], then the annual conservation will comprise $\Delta T \approx \Delta Э_{СН} \cdot m$ or with regard to substitution of the values of $\Delta T \approx 4202320 \cdot 0.328 = 1{,}378.4$ tons of conventional fuel. The fuel conservation per generated kW·hr can be determined by the ratio

$$\Delta m = \frac{\Delta T}{Э}$$

or

$$\Delta m = \frac{1378{,}4 \cdot 10^{6}}{200 \cdot 10^{3} \cdot 7605} = 0{,}9 \text{ g/(kW·hr)}.$$

To estimate the return of investment of the drive, one must determine the cost of the conserved electric power $Ц_Э$ when using the regulated electric drive:

$$Ц_Э = C \cdot \Delta Э_{сн},$$

where C is the average cost of electric power, determined in calculation for each specific case.

Moreover, one must take into account yet another component of conservation, related to a reduction of expenditures for repair of the switches and asynchronous drive motors. The return of investment of the regulated drive, which includes the thyristor frequency converter, depends on the cost of the converter and also on the expenditures for installation and adjustment of it.

Calculations with respect to the circuit in this analysis for a 200-MW power-generating unit show that the return of investment will be approximately 4 years, which is quite acceptable for this complex drive, at average cost of electric power for the Moldavia GRES equal to 0.8 kopecks/(kW·hr) and at cost of the frequency converter with power of 4,000 kW, with voltage of 6 kV and with installation and adjustment costing 100,000 rubles (according to data of the PO [Production Association] TEZ imeni M. I. Kalinina [possibly Togliatti Electrical Engineering Plant imeni M. I. Kalinin]).

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UDC 629.124.791.011.762:534.647

ACOUSTIC VIBRATION OF OUTER PLANKING OF ICEBREAKERS

Leningrad SUDOSTROYENIYE in Russian No 5, May 86 pp 9-11

[Article by L. S. Boroditskiy]

[Text] Estimation of the average levels of acoustic vibration of the outer planking, caused by impacts of ice against the hull, is of interest from the viewpoint of the problem of habitability of modern icebreakers. Excitation of the outer planking plates is a pulsed random process. Let us consider the vibrations of the plates, induced by a random sequence of ice impacts during determinant distribution of external forces.

The equation of bending vibrations of the plate exposed to random pulses has the form

$$\bar{D}\Delta\Delta w + m\ddot{w} = \psi(x, y)\sum_i f_{\tau_i}(t - t_i),$$

where $f_{\tau_i}(t - t_i)$ is the time dependence of the i-th pulse of length τ_i ($f_{\tau_i} = 0$ at $t_i > t > t_i + \tau_i$), τ_i, t_i and the amplitude of function f_{τ_i} is random values, $\psi(x, y)$ is the pressure distribution function over the area of the plate, $\bar{D} = D(1 + i\eta)$ is the complex cylindrical stiffness, m is the surface mass of the plate and η is the loss factor.

If the frequency range above the first natural frequency of bending vibrations of the plate is considered, it is convenient to assume that the plate is freely supported. After expansion of the functions w(x, y, t) and $\psi(x, y)$ into a double series by sines and after integration of both sides of the equation for the area of the plate, we find for the kn-th vibration mode of the plate the equation

$$\ddot{w}_{kn}(t) + \bar{\omega}_{kn}^2 w_{kn}(t) = a_{kn}/m \sum_i f_{\tau_i}(t - t_i), \qquad (1)$$

where $a_{kn} = \frac{4}{ab}\int_0^a \int_0^b \psi(x, y) \sin\frac{k\pi x}{a} \sin\frac{n\pi y}{a} dx dy$; $\bar{\omega}_{kn}^2 = \frac{\bar{D}}{m}\left[\left(\frac{k\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2\right]^2$; and a and b are the sides of the plate.

Expression (1) is the well-known equation of vibrations of a one-mass system exposed to random forces.

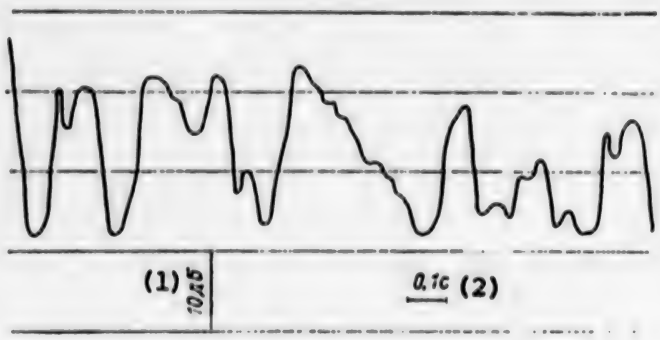

Figure 1. Dependence of Total Vibration Levels of Outer Planking of Icebreaker During Motion in Broken Ice of Density 8 at Speed of 10 Knots

KEY:
1. dB
2. s

Recordings of the vibration levels of the outer planking of the icebreaker, at large thickness of which the frequency of natural vibrations is so high that the duration of the ice impacts is usually greater than the period of the natural vibrations, are presented in Figure 1. Accordingly, one can assume that the time dependence of acceleration and forces acting on the plate are identical. This means that the statistical characteristics of the impact amplitude, the interval between impacts and their duration can be determined from the recordings of the vibration levels.

The dependence of the range of the random pulse process on the range of a single pulse and on the statistical characteristics of the lengths of pauses between pulses and on the lengths of the intervals between the moments of occurrence of the pulses is presented in [1].

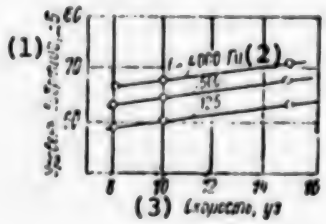

Figure 2. Dependence of Vibration Levels of Outer Planking on Speed During Navigation in Broken Ice: circles correspond to experimental data

KEY:
1. Vibration level, dB
2. Hz
3. Speed, knots

Statistical processing of the recordings of the vibration levels on icebreakers showed that the law of distribution of the lengths of pauses is close to steady. In this case, according to [1], the spectrum of the total pulses is similar to that of a single average pulse. This conclusion permits one to permit replacement of the sum of random pulses in the right side of equation (1) by the sum of identical pulses of average value and of duration during the average interval between pulses. If one assumes that the pulses are square-wave types, the periodic part of the solution of equation (1) for a concentrated force has the form:

$$w_{kn}(t) = \frac{4F_{max} \sin \frac{k\pi a}{a} \sin \frac{n\pi b_1}{b}}{mab\bar{\omega}_{kn}^2} \frac{\sin \frac{\bar{\omega}_{kn}\tau}{2}}{\sin \frac{\bar{\omega}_{kn}T}{2}} \times$$

$$\times \cos \omega_{kn}\left(t - \frac{T+\tau}{2}\right),$$

where F_{max} is the force in a square-wave pulse, τ is the average duration of the pulse, T is the mean period of the pulses and a_1 and b_1 are the coordinates of the points of application of the force.

For convenience in comparison to experimental data, it is of interest to calculate the sum of displacements (accelerations), average with respect to the area of squares of the amplitudes, on kn-th modes, the natural frequencies of which are inside the given frequency band, for example, in an octave or semioctave band. Let us use the procedure of replacing the summation by integration with respect to k and n [2] and let us use for the square of acceleration the following expressions:

at $\omega\tau < 0.2$

$$\langle \ddot{w}^2 \rangle_{okt} = \frac{F_{max}^2 (\tau\omega)^2}{2\pi m^2 Dab\eta T}; \qquad (2)$$

at $\omega\tau > 0.2$

$$\langle \ddot{w}^2 \rangle_{okt} = \frac{F_{max}^2}{\pi m^2 Dab\eta T}; \qquad (3)$$

ω is the average frequency of the octave band.

The condition $\omega\tau < 0.2$ is not fulfilled for the audio band at realistic pulse lengths; therefore, expression (3) will be used to estimate the levels of acoustic vibration.

Formulas (2) and (3) contain an unknown value--the force of impact F. To estimate it, let us consider the equation of motion of a floating ice floe of mass M, having the shape of a flat cylinder, which comes into contact with an absolutely rigid body of infinite mass, the speed of which is v_0. Let us assume

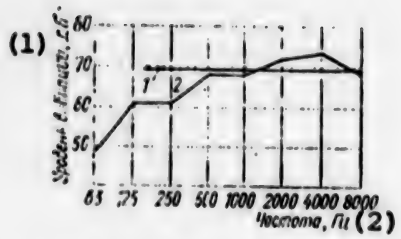

Figure 3. Vibration Levels of Plate: 1--calculation; 2--measurement results

KEY:

1. Vibration level, dB
2. Frequency, Hz

that the speed of the body v_0 remains constant during the entire period of increase of load at the point of contact with the ice floe. The physical pattern of the increase of load upon impact is based on the fact that ice is a material with relatively low bearing strength (σ_s) [3]. Because of inertia, the ice floe acquires a speed of v_0 after a certain time $t = \tau$, during which it is partially broken up. The load will increase during the entire time $t \leq \tau$ until the force breaking up the ice floe becomes equal to its force of inertia.

Let us introduce the following notations for consideration of the motion of an ice floe: $x_1(t)$ is the displacement of the body, $x_2(t)$ is the displacement of the center of gravity of the ice floe and $\xi(t)$ is the collapse of the ice floe in direction x. There is the following ratio between these values: $x_1(t) = v_0 t = x_2(t) + \xi(t)$. Let us assume that the broken-up part of the ice floe is small compared to the unbroken part, and the equation of motion of the floating ice floe then has the form

$$(M_п + M)\ddot{x}_2(t) = \sigma_s S(t),$$

where S(t) is the contact area of the body with the ice floe (the collapse area) and $M_п$ is the reduced mass of the water, dependent on the geometric shape and dimensions of the ice floe. It follows from the kinematics of collapse for a cylinder that $S(t) \approx 2\sqrt{2}\sqrt{R}h\sqrt{\xi(t)}$ (R is the radius of a cylinder and h is height). Taking into account that $\ddot{x}_2(t) = -\ddot{\xi}(t)$, one can find the following differential equation for determination of the extent of collapse:

$$(M + M_п)\ddot{\xi}(t) + 2\sqrt{2}h\sqrt{R}\sigma_s\sqrt{\xi(t)} = 0. \tag{4}$$

The initial conditions for determination of the integration constants of this equation are $\xi(0) = 0$, $\dot{\xi}(0) = v_0$.

Equation (4) is nonlinear. After reduction of the order of the equation and after solution ot it by the Piccard method in second approximation, we find

$$\xi(t) \approx v_0 t - 2/15 v_0^{1/2} k^2 t^{5/2}, \tag{5}$$

where $k^2 = 2\sqrt{2}h\sqrt{R}\sigma_s/M + M_п$ ($M_п \simeq \pi\rho R^2 h$).

We find $\tau = (9/2)^{1/5}\pi^{2/5}R(\rho/\sigma_s)^{2/5}v_0^{1/5}$. from the equation $\ddot{\xi}(\tau) = 0$. Substituting this value into the expression for the bearing strength $F(\tau) = \sigma_s S(\tau)$, we have

$$F(\tau) = \frac{6}{\sqrt{15}}\pi^{1/5}Rh(v_0\tau_s)^{2/3}\rho^{1/5}. \qquad (6)$$

It is of interest to compare the calculated values of τ and the experimental data found directly when recording on an automatic recorder the vibration levels of the outer planking of an icebreaker during navigation in broken ice (see Figure 1). At $v_0 = 2$ m/s and $\sigma_s = 2.0 \cdot 10^6$ N/m^2, the time of increase of the load in seconds is $\tau = 2.5 \cdot 10^{-2} \cdot R$, where R is in meters. As can be seen from the recordings, the time of increase of the load is on the order of hundredths and thousandths of a second, which is in agreement with calculated data.

The bearing forces acting on the plates of the outer planking, as can be seen from formula (6), are proportional to $v_0^{2/3}$. Accordingly, the vibration amplitude of the plates should be proportional to the same extent to speed. The dependence of the vibration levels of the outer planking of an icebreaker on its speed with constant ice situation is presented in Figure 2. As can be seen from the graph, the vibration levels increase by approximately 5 dB (calculated for 4 dB) if speed is doubled.

The values $F(\tau) = F_{max}$, calculated by formula (6), should be substituted into expressions (2) and (3) to estimate the vibration levels. As an example, let us calculate the vibration levels of the plate of the outer planking of an icebreaker measuring $(2.0 \times 0.7 \times 5.0)10^{-2}$ at icebreaker speed of 12 knots. The angle of inclination of the side to the centerplane is 8°. Let us take as the mean force the impact of a floating ice floe in the form of a flat cylinder with radius 0.5 m and height 0.3 m. The loss factor is assumed equal to $\eta = 5 \cdot 10^{-3}$, the average interval between impacts at the indicated speed is approximately 0.2 s and the duration of the impact is 0.01 s. The vibration levels of the outer planking of an icebreaker, measured under conditions of navigation close to those described above, are shown in Figure 3. Sufficient matching of the calculated and experimental results is observed in the range of medium and high frequencies.

Thus, the functions permit one, at least qualitatively, to estimate the effect of speed, the characteristics of the ice and the parameters of hull designs on the average vibration levels of the outer planking of an icebreaker. Together with the results of full-scale measurements of noise and vibration, this creates the basis to work out calculating methods for predicting the noise levels in the spaces of icebreakers during navigation in ice.

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UDC 629.12.073/074.001.5

SHIP SURVIVABILITY: A COMPLEX CONCEPT

Leningrad SUDOSTROYENIYE in Russian No 4, Apr 86 pp 10-11

[Article by V. A. Gorbachev]

[Abstract] Only 15% of accidents and damage to ships and their equipment is due random circumstances unrelated to the actions of the crew. Any evaluation of ship survivability must thus consider the "ship - crew" system. This paper is a general discussion of the application of systems analysis to ship survivability that defines survivability as the capability of the "ship - crew" system to predict trouble and prevent it. There are three basic groups of measures that must be implemented to assure ship survivability and safety: 1) The design solutions incorporated in a ship and used in its construction; 2) The organizational and technical measures implemented during operation for the purpose of preserving the initial design values for the survivability, which also enamble the prediction of accidents; 3) The measures that promote survivability and safety, i.e. crew actions directed towards damage control and the restoration of the requisite functional level. A block diagram illustrates the interrelationship between the factors of these three groups that govern ship survivability. A simple analytical expression is adduced for ship survivability as a comprehensive quality of a ship, written in terms of the probability of failure-free operation of the "ship - crew" system, based on the above breakdown of the responsible factors into three groups. This probability is not constant during the operational life of a ship, but the expression given here is nonetheless an improvement in the probabilistic representation of the concept of survivability formalized in earlier literature. No specific applications or examples are cited. Figures 1; references: 5 Russian.

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CSO: 1861/370

UDC 621.865.8:69.002.5

MANIPULATORS AND ROBOTS IN CONSTRUCTION

Moscow STROITELNYYE I DOROZHNYYE MASHINY in Russian No 2, Feb 86 pp 11-14

[Article by Doctor of Technical Sciences V. I. Balovnev, engineer G. D. Moiseyev (Moscow Motor Vehicle and Roads Institute) and Doctor of Technical Sciences L. A. Khmara (Dnepropetrovsk Engineering Construction Institute)]

[Text] Development of new technology of construction work must primarily be begun for successful and extensive use of robots in construction, by reviewing the methods of production with regard to the possible use of robots. The current state of the art of construction technology makes step-by-step solution of robotization of construction necessary.

Extensive use of universal and specialized construction manipulators with automated control is feasible in the first phase, under conditions when construction technology has not been adapted to the use of robots.

The time for extensive use of robots in construction begins in the second phase, when construction technology is being transformed to one that fully takes into account the capabilities of robotization.

Universal construction manipulators with manual or automated control are already solving a number of timely production tasks: they are increasing labor productivity, considerably reducing material, energy and labor expenditures and injuries and are freeing workers of performing exhaustive, laborious and unpleasant manual operations. Compared to robots, manipulators are structurally simpler and considerably less expensive.

The construction manipulator [1] is a device, controlled remotely by the operator and designed to perform diverse construction operations that are primarily related to execution of monotonous, heavy and dangerous jobs. It is distinguished from other types of construction machinery by a working member that simulates the motion of the human arm, but is also capable of performing functions not inherent to the human arm.

The main classification features of manipulators and robots are presented in the block diagram.

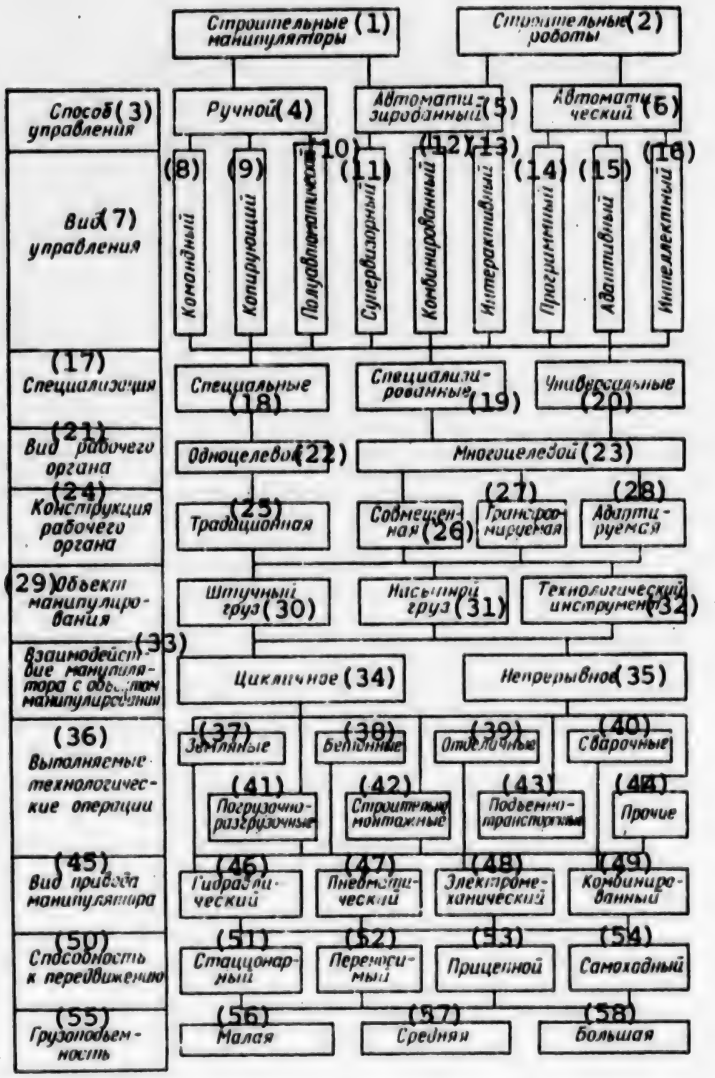

Diagram of Main Classification Features of Construction Manipulators and Robots

Key:

1. Construction manipulators
2. Construction robots
3. Method of control
4. Manual
5. Automated
6. Automatic
7. Type of control
8. Command
9. Master-slave
10. Semiautomatic
11. Supervisor
30. Piece goods
31. Bulk cargo
32. Production tools
33. Interaction of manipulator and object of manipulation
34. Cyclic
35. Continuous
36. Production operations to be performed
37. Earth-moving
38. Concrete

[Key continued on following page]

12. Combination
13. Interactive
14. Programmed
15. Adaptive
16. Intelligent
17. Specialization
18. Special
19. Specialized
20. Universal
21. Type of working member
22. Single-purpose
23. Multipurpose
24. Design of working member
25. Traditional
26. Integrated
27. Transformable
28. Adaptable
29. Objective of manipulation
39. Finishing
40. Welding
41. Loading-unloading
42. Construction-installation
43. Hoisting-transport
44. Miscellaneous
45. Type of manipulator drive
46. Hydraulic
47. Pneumatic
48. Electromechanical
49. Combination
50. Capacity for moving
51. Stationary
52. Portable
53. Towed
54. Self-propelled
55. Capacity
56. Small
57. Medium
58. Large

Construction manipulators can be controlled manually by three methods: by command with separate control of each stage of mobility of the manipulator, by master-slave through a master unit, kinematically similar to a manipulator, and semiautomatic using a multistep arm with arbitrary kinematics.

Automated construction manipulators may have supervisory control when the operator only includes the corresponding automatic program, they may have combination control, which combines manual and supervisory control, and they may have interactive control, when both the operator and the control unit can make a decision.

Manipulators are divided by design of the working members into traditional for performing a single standard construction operation, they may have combined equipment when two or more working members are installed on the same platform, transformable, equipped with an automatic grab and set of interchangeable working members, and adaptable, equipped with a multipurpose working member for performing a number of production operations [3].

The classification can also be supplemented by features that determine the number of degrees of freedom, the volume of the work envelope the method of programming, the type of movable unit, the structural-configuration layout and so on. The simplest are manipulators with restricted number of operations to be performed, optimal for the corresponding production cycle: digging and accompanying operations related to renovation of objects and so on.

Stationary specialized manipulators for concrete-laying operations have become widespread [4]. This manipulator (Figure 1) is an articulated-jointed box-like arm with hydraulic drive, which carries hoses for delivery of concrete. One man controls the manipulator by four command levers. The area to be serviced is approximately 880 m^2, the power of the drive is 7.5 kW and the weight is 4,513 kg. The use of the manipulator increases labor output by 30 percent.

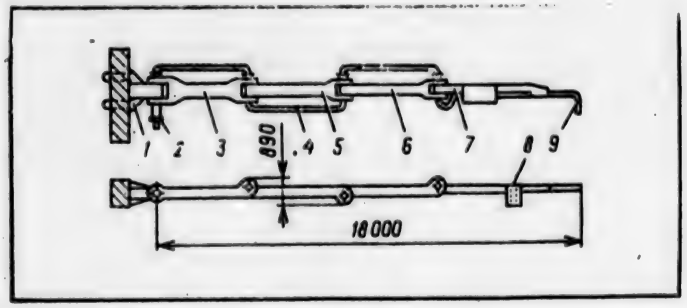

Figure 1. Manipulator for Concrete Laying Operations: 1--holder; 2--pipe union for delivery of concrete; 3, 5, 6, 7--sections; 4--concrete delivery pipeline; 8--control console; 9--flexible hose

A universal construction manipulator with adaptable working member for earth-moving and accompanying operations can have different capacity. It can be mounted on the chassis of excavators, tractors and loaders of various dimensions. Specifically, such a manipulator, developed at MADI [Moscow Motor Vehicle-Roads Institute]--DISI [Dnepropetrovsk Engineering Construction Institute] [3], is mounted on the EO-2621V hydraulic mechanical shovel. Maintaining complete efficiency during operation of the backhoe, the machine with the proposed working member performs those production manipulator operations which require the use of specialized machines or are now performed manually.

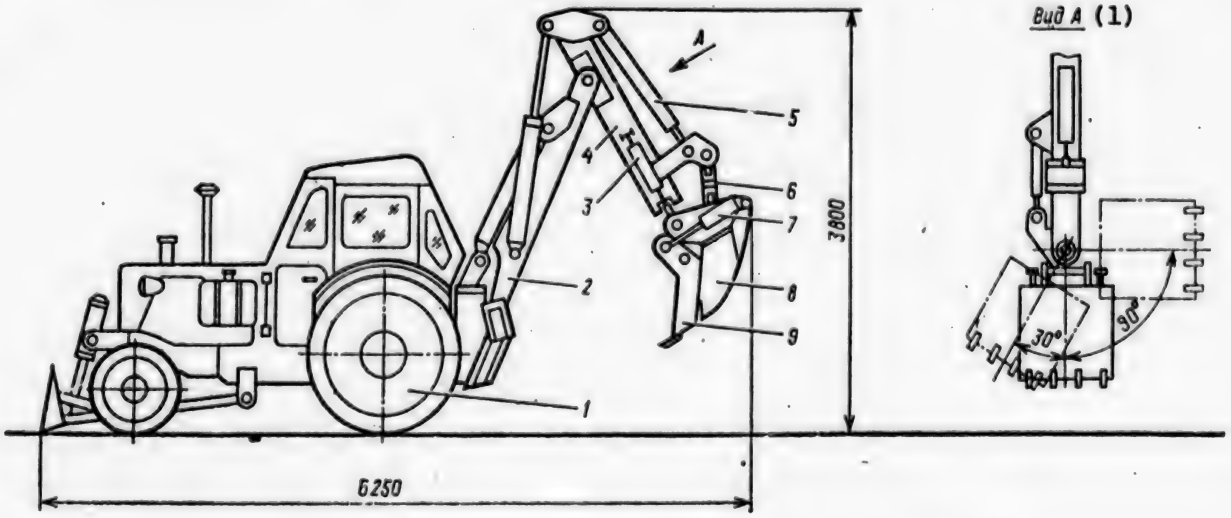

Figure 2. Universal Construction Manipulator Designed by MADI-DISI: 1--base machine; 2--boom; 3--hydraulic cylinder for rotation of scoop; 4--arm; 5--hydraulic cylinder for rotation of scoop in plane of slave member; 6--articulated rod; 7--hydraulic cylinder for control of scoop jaw; 8--scoop; 9--jaw

Key:

1. View A

The operating equipment (Figure 2) is a scoop, equipped with a jaw grab with double-jointed insert, with the presence of which the working member achieves an additional degree of freedom. This imparts the qualities of a manipulator to it and supports execution of a number of production operations, which cannot be performed by the ordinary operating equipment of a shovel. Standard teeth are provided in the front part of the jaw grab and a linear cutting blade is provided in the rear part. The main scoop also has a linear knife. The jaw grab, articulately connected to the scoop, is controlled by hydraulic cylinders. The scoop is connected to the arm of a double-jointed insert with mutually perpendicular axes of the joints and is connected by a universal rod and two-section lever to the coupling rod of the hydraulic cylinder for rotation of the scoop. A lever, which is articulately connected to the hydraulic cylinder for rotation of the insert, is rigidly fixed to the double-jointed insert.

The manipulator performs a combination of operations: digging with the backhoe and clamshell, cleaning and grading operations, slope formation, ripping with one tooth, digging near the walls of buildings, loading-unloading operations of piece and bulk goods, manipulator operations with separate objects, grasping of interchangable working members: jackhammer, hydraulic tamper and so on.

An even greater effect in reduction of labor expenditures can be achieved through extensive use of robots, which are automatic machines, consisting of a manipulator and programmable control unit [5]. An example may be the first-generation construction robots with rigid program control. Robots of special designation are used extensively: for guniting, for application of fire-resistant coatings to metal construction sections and so on [4].

A robot for guniting of concrete during construction of tunnels is a partially automated self-propelled hydraulic manipulator with supervisory control elements, which can be installed on a hydraulic excavator instead of a scoop, on a heading machine, on a self-propelled carriage and so on. The parameters of the robot installed on an excavator are 8 m high, 7.2 m wide and total weight of 10,500 kg. When applying a layer of concrete, the guniting head makes automatic horizontal forward-reverse movements.

A self-propelled construction robot with rigid program control has been developed and tested for application of fire-resistant coating to steel sections of buildings. It operates on the teaching-playback principle and increases labor output approximately twofold. The mass of the robot is approximately 700 kg, that of the self-propelled tractor is 325 kg and control of the movement of the tractor is electromagnetic induction.

The future use of robots in construction, which not only operate according to a rigid program, but are also adaptable by means of sensors to a change of the surrounding situation (second-generation adaptive robots) and which have the capability of working out and making a decision (third-generation intelligent robots) is possible.

A specialized second-generation self-propelled robot for drilling shot holes when driving tunnels, which automatically performs all drilling operations,

including setting the robot on the main platform of the face, determination of the location of shot holes and drilling the shot holes according to a previously written program by the teaching method, is shown in Figure 3. Moreover, the robot is supplied with environmental adaptation sensors, which permits it to omit the shot hole in case the guide unit encounters rocks and to transfer to the location for drilling the next shot hole. The force of delivery, the rotational frequency and force of the drill impact are regulated during drilling as a function of properties of the rock; the locations of the shot holes are selected for formation of the given mining profile. The robot weighs 33,80 kg, the zone of drilling horizontal shot holes is 7.5 m high and 16.7 m wide and the power of the hydraulic propulsion unit is 7 kW. The robot decreases the standard deviation of the location of shot holes by a factor of 1.7 with essentially equal rate of driving compared to manual control and it increases the precision of observing the mining profile 2.5-fold and it improves overall safety [6].

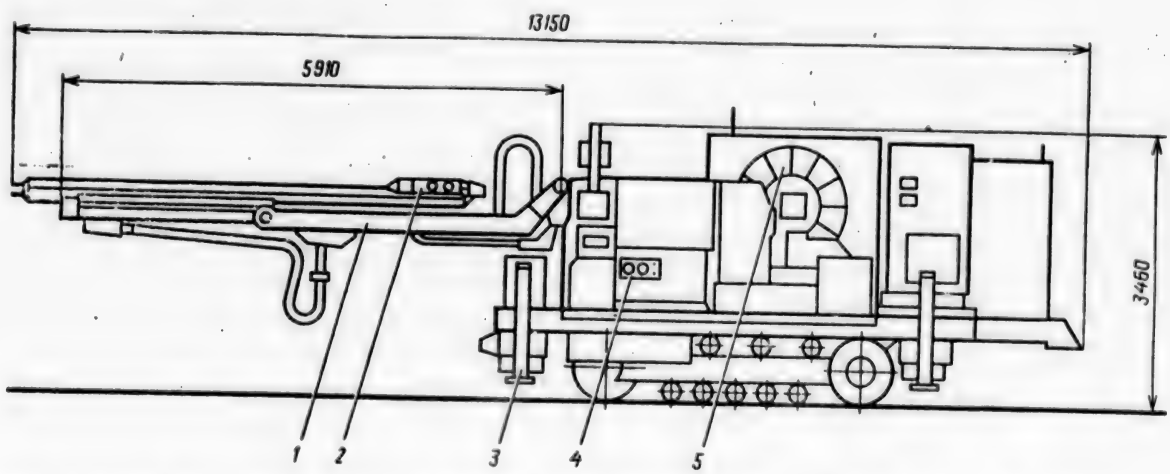

Figure 3. Second-Generation Robot for Drilling Shot Holes When Driving Tunnels: 1--boom; 2--drilling machine with hydraulic unit; 3--extensible supports; 4--control unit; 5--cable drum

Analysis of information on the use of manipulators and robots in construction permits a number of conclusions.

Development of highly efficient construction manipulators and robots and also reduction of the periods of introducing them require solution of a number of primary scientific problems. These are working out statistical models of the operational background and types of operations with regard to the complexity and laboriousness of performing them, development and optimization of the parameters of the lever system of manipulators and robots as a function of the parameters that characterize the operating technology, development and operation of the parameters of the lever system of manipulators and robots as a function of the parameters that characterize the operating technology, development and optimization of slave units--special-purpose and multipurpose grabs, working out methods of dynamic analysis and calculation of manipulators and robots, determination of the areas of optimum application and estimation of the technical level and competiveness of construction manipulators and robots as a function of the number of operations to be performed, their type, the probability of appearance, volume and other factors.

The most important problem for effective use of manipulators and robots in construction is the presence of trained specialists who are capable of working with the new high-performance and more complex equipment. Simple replacement of old methods and devices by new ones does not yield the desired effect. It is necessary to begin now to develop the methods of operating manipulators and robots in specialized subdivisions. It is important to begin training of personnel in design and operation of the corresponding equipment. The training of technicians and engineers in the field of production technology and mechanization of construction must be intensified in the part that concerns methods and means of robotization of construction.

Implementation of high rates of robotization of construction is impossible without timely implementation of measures to train highly skilled operators, technicians and engineering personnel who are capable of solving the problems of developing construction manipulators and robots and of using them efficiently in construction.

USSR Gosstroy, planning organizations and machine-building organizations must formulate a scientifically substantiated concept for extensive use of construction manipulators and robots in construction technology. The designs of structures should be oriented toward erecting them by using manipulators and robots. Production technology should be modified on a robotized basis. The types, volumes and probabilities of operations appearing for manipulators and robots must be determined.

Construction must be supplied with manipulators and robots of different level of complexity with multipurpose and single-purpose working members to perform single, frequently repetitive jobs and a wide range of diverse low-volume jobs, heavy unpleasant jobs and so on. The main criteria of the effectiveness of robotization of construction are the economic indicators of energy, material and labor resources and a reduction of the construction deadlines.

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STATISTICAL CORRELATION BETWEEN DENSITY AND MOISTURE CONTENT OF STRUCTURAL MATERIALS UNDER INSPECTION BY RADIATION METHODS

Moscow BETON I ZHELEZOBETON in Russian No 5, May 86 pp 16-17

[Article by S. L. Davydov, engineer, V. G. Kopytov, engineer, N. L. Rynin, candidate of technical sciences, and Kh. Kh. Sternin, candidate of technical sciences, Leningrad Zonal Scientific Research Institute of Standard and Experimental Design of Residential and Communal Buildings]

[Abstract] An extensive experimental study of structural materials and their inspection with neutrons and γ-rays was made by the Leningrad Zonal Scientific Research Institute of Standard and Experimental Design of Residential and Communal Buildings jointly with the Riga Scientific Research Institute of Radioisotope Instruments and the All-Union Scientific Research Institute of Physico-technical and Radiotechnical Measurements, for the purpose of evaluating the performance of 2π albedo transducers. A statistical correlation between density and moisture content as well as its effect on the accuracy of measurements on the basis of interaction of neutron and gamma radiation with the material has been established for materials covering the 1000-2500 kg/m^3 density range (perlite sand, river sand, granite detritus of the 5-10 mm size friction, dry and hydrated BTTs-M500 Portland cement from the Volkhov Plant, and silicate glass) with 0-30 vol.% moisture contents. A sequential multifactorial regression analysis of the experimental data, with the aid of a YeS-1022 computer using the Step R program, has yielded two simple empirical expressions relating density and moisture content to one another as well as to instrument readings in the neutron channel and in the gamma channel, and also to the relative density sensitivity of a neutron flux. Tables 1; references: 1 Russian.

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USE OF BETATRONS FOR QUALITY CONTROL OF STRUCTURES

Moscow BETON I ZHELEZOBETON in Russian No 5, May 86 pp 17-19

[Article by V. A. Klebtsov, doctor of technical sciences, professor, Yu. K. Matveyev, engineer, Scientific Research Institute of Reinforced Concrete, and V. V. Trefilov, engineer, Design and Technological Office, Scientific Research Institute of Reinforced Concrete]

[Abstract] A new small-size betatron MIB-4 is now produced commercially and the old small-size betatron PMB-6 has been updated for nondestructive quality control of reinforced-concrete building structures. Both were evaluated in laboratory experiments according to the GOST [State Standard] 17625-83 procedure, which had been refined so as to facilitate void detection in the concrete as well as flaw detection in the reinforcement. They were used in x-radiographic tests on specimens of heavy concrete with granite and lime filler. Voids of cubical, spherical, cylindrical, prismatic shapes were intentionally introduced, whereupon reinforcement grids with circular or periodic profiles using rods of various diameters were inserted. On the basis of data recorded on RT-1, RT-2, RM-1 x-ray films and analyzed for reliability, techniques have been devised for using these betatrons where access to structural members of a building is accessible from all four sides or from two sides only. These techniques were applied staff of the Belorussian Polytechnic Institute to inspection of a sawtooth roof on one of the buildings of the Minsk Worsted Fabrics Manufacturing Combine. Figures 2; references 1: Russian.

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UDC 699.81

PROPERTIES OF HARDENED STEEL AFTER FIRE

Moscow BETON I ZHELEZOBETON in Russian No 5, May 86 pp 34-35

[Article by V. V. Solomonov, candidate of technical sciences, Scientific Research Institute of Reinforced Concrete, and A. V. Pchelintsev, engineer, Moscow Institute of Construction Engineering imeni V. V. Kuybyshev]

[Abstract] An experimental study of hardened steel for concrete reinforcement was made, the purpose being to determine its fire resistance. Rods of thermomechanically hardened class At-V and grade 20MnSi steel, 10 mm in diameter and 900 mm long, were heated while under a stress of 420-550 MPa in a furnace with asbestos stuffing of the insertion holes. They were heated to temperatures up to 600°C, to which they would be exposed during a fire when embedded in 20 mm thick concrete slabs. After slow cooling to 20°C, they were tested for changes in ultimate tensile strength and 0.2%-set yield point. The

ultimate tensile strength was found to decrease only after heating above 350°C, the magnitude of the decrement increasing from 3-5% (350°C) to 33-35% (600°C). The yield strength was found to first increase after heating above 100°C, the magnitude of the increment increasing from 1% (200°C) to 12-13% (350°C) and decreasing to 0 (450°C), and then to decrease after heating above 450°C. The results agree within 3-8% with results of mechanical tests after heating by electric current to such temperatures and then cooling to 20°C. Such tests should be included in norms and procedures pertaining to fire-proof reinforced-concrete design. Figures 1; references 2: Russian.

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HEAVY CONCRETE WITH ASH-SOOT ADMIXTURE

Moscow BETON I ZHELEZOBETON in Russian No 5, May 86 pp 39-40

[Article by A. M. Girzhel, candidate of technical sciences, V. G. Braginskiy, candidate of technical sciences, and V. I. Romanov, engineer, Donetsk Scientific Research Institute of Industrial Construction Planning]

[Abstract] While total replacement of cement with ash and soot from thermal electric power plants is known to lower the strength of concrete, partial replacement has been found to be both technically and economically feasible so as to merit a more thorough investigation. A study was made with M-500 Portland cement from the Ambrosiyev Combine, fine sand (1.7 mesh modulus), granite gravel (5-20 mm) from the Zaporozhye quarry, and sooty ash from the Uglegorsk GRES. The ash, containing 52.3% SiO_2+ 25.3% Al_2O_3+ 13.9% Fe_2O_3+ (CaO,MgO,Na_2O,K_2O,FeO,SO_3), had been extracted from one set of electrostatic air filters. It had an intrinsic density of 2260 kg/m^3, a bulk density of 900 kg/m^3, and a specific surface area of 4000 cm^2/g. Concrete with various Cement:Ash:Sand:Gravel:H_2O ratios was poured into cubical molds and after 4 h cured by heating at 90-95°C in a 4+6+3 h cycle. Specimens were then 4 h and 28 h later tested for mobility, density, and compressive strength. A regression analysis of the data, with the aid of standard formulas, has confirmed the advantages of partial cement replacement with ash and soot as microfiller. The saving in cement can reach 100 kg/m^3 of concrete with temper strength equal to 70% design strength and 180 kg/m^3 of concrete with temper strength equal to 100% design strength. Figures 4; tables 2; references 4: all Russian.

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UDC 629.735.45

COST EFFECTIVENESS OF INSTALLATION OF EQUIPMENT FOR ELECTRIC POWER TRANSMISSION LINES WITH AID OF HELICOPTERS

Moscow ENERGETICHESKOYE STROITELSTVO in Russian No 4, Apr 86 pp 59-61

[Article by V. N. Zagnitko, engineer, G. N. Elenbogen, engineer, N. I. Yevplov, candidate of economic sciences, and R. D. Tokhunts, candidate of technical sciences]

[Abstract] The economic feasibility of installation of equipment for overhead electric transmission lines by helicopter than from the ground is examined, assuming that operations are properly planned and scheduled. Calculations are based on standard cost analysis methods, with the total present cost as minimizable target function. Into account are taken not only referred costs including return on capital investment but also cost savings derived from shorter installation period and smaller right-of-way as well as reduced need for temporary facilities and lesser detriment to adjacent farm land. An analysis on the basis of data pertaining to installation of specific power lines, at current prices, can yield results indicating that use of helicopters is not cost effective within the narrow scope of the electric power distribution enterprise but is cost effective within the broader scope of the national economy. The latter should serve as the overriding criterion. Tables 1; references: 3 Russian.

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UDC 621.315.17.629.735.45

COMPREHENSIVE USE OF MI-10K HELICOPTER FOR TRANSPORTING AND POSITIONING GANTRY-TYPE SUPPORTS FOR DEMYANSK-KONDA 220 kV OVERHEAD POWER TRANSMISSION LINE

Moscow ENERGETICHESKOYE STROITELSTVO in Russian No 4, Apr 86 pp 62-64

[Article by O. V. Karabayev, engineer, V. F. Ovchinnikov, engineer, and V. S. Patrushev, engineer]

[Abstract] During installation of the Demyansk-Konda 220 kV power transmission line, all-round use was made of Mi-10K helicopters for transporting and positioning gantry supports. The technology had been developed earlier, but only partially employed for other 110-500 kV power transmission lines. Two methods were employed in this project. The first method was to transport a support from the yard to the marked site and then drop it from above, installing one leg at a time, into retainers already in the ground. Subsequent work was being done by the erection crew, while the helicopter returned to the yard for the next support. In the second method the support's legs were dropped into receptacles with spring-loaded clamps and then swinging it into

a vertical position on these "hinges" with the helicopter. Preparatory work such as transporting the crew and the retainers had been done with use of an MI-8 helicopter. A total of 66 gantries was installed in this way during the summer and fall period, which cost 298,000 rubles less than without helicopters. The total installation cost of the power transmission line was 12.9 million rubles, including 1.4 million rubles for rental of helicopters. Figures 3; tables 1; references: 5 Russian.

2415/12947
CSO: 1861/518

UDC 629.735.45

USE OF HELICOPTER TECHNOLOGY IN CONSTRUCTION OF ELECTRIC POWER GRIDS

Moscow ENERGETICHESKOYE STROITELSTVO in Russian No 4, Apr 86 pp 64-65

[Article by G. S. Maltsev]

[Abstract] During the 11th Five-Year Plan period helicopters were extensively used in installation of overhead electric power transmission lines: 500 kV lines (Khabarovsk--Komsomolsk-na-Amure in Eastern Siberia, Ingursk GES--Stavropolsk GRES at 3000 m above sea level in the Caucasus), 330 kV lines (Kola AES--Nikel substation), 220 kV lines (Inta--Vokutra, Pechora--Inta, Pechora--Usinsk in the Komi ASSR and Khabarovsk--Komsomolsk-na-Amure parallel to the 500 kV line). Crews, transmission towers, reinforced-concrete retainers, and anchor-angle supports were transported mainly by MI-10 K helicopters but also MI-8 and MI-2 helicopters. This technology is increasingly employed in regions with difficult climate and terrain. There are still problems to be resolved and improvement to be made with regard to food supply, medical care, transportation, and radio communication for the helicopter crews, adding special helicopter operating equipment, preparation of the transmission line routes in accordance with USSR Ministry of Civil Aviation requirements, and training the erection crews in working with helicopters. Figures 1.

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UDC 658.52.001.56:621.165

AUTOMATION - BASIS FOR RAISING PERFORMANCE LEVEL OF STEAM TURBINES

Moscow ENERGOMASHINOSTROYENIYE in Russian No 3, Mar 86 pp 17-19

[Article by V. V. Malev, engineer, and M. S. Fragin, candidate of technical sciences]

[Abstract] Automation is the basic tool now available for raising the performance level of steam turbines, but effective only when integrated with automation of all other components of the power generating system and economically feasible only with maximum standardization of the automation hardware including microcomputers. Most essential and critical is automatic regulation of the steam rate, which requires automation of the electrohydraulic system controlling it. The latest (1984) version of the electrical part of the regulating system (EChSR-M) for high-power steam turbines manufactured at the Leningrad Metal Works includes two V7 microcomputers with software produced at the All-Union Institute of Electrical Engineering imeni V. I. Lenin. The two micros "spot" for each other, swapping back and forth from active to standby in "hot" reserve. Control of valves now also solves the problem of reliability assurance during overspeed operation after load dumping from the generator, power regulation during emergencies and correction of initially irregular speed regulation with a fast-response electrohydraulic converter, and power regulation under normal conditions with a slow-response electrohydraulic converter. The regulation system can function in three modes: automatic starting of the turbine, power regulation, and limiting the underpressure of live steam. The capabilities of an EChSR-M microprocessor include diagnostic analysis of mechanical, thermodynamic, and heat transfer processes. References 4: all Russian.

2415/12947
CSO: 1861/511

UDC 620.197.6

SELECTION OF COATING SYSTEM FOR TIMES PROTECTION OF STEAM AND GAS TURBINES

Moscow ENERGOMASHINOSTROYENIYE in Russian No 3, Mar 86 pp 41-42

[Article by Zh. V. Misler, candidate of chemical sciences, I. V. Yelisavetskaya, candidate of chemical sciences, Yu. D. Sklyarov, engineer, Ye. A. Zvezdina, engineer, and G. N. Blagorodova, engineer]

[Abstract] For health protection and fire prevention, toxic varnish-and-paint coatings with organic solvents on surfaces of steam and gas turbines need to be replaced. Accelerated climatic tests and field tests on a K-300-240 LMZ (Leningrad Metal Works) steam turbine have yielded sufficient data for recommending two new coating systems for safe corrosion protection in moderate climate and in tropical climate respectively. They consist of a primer, black E-KCh-0184 or E-KCh-0186 produced at the "Lakokraska" plant in Yaroslavl and easily removable "Nitrilats" varnish produced at the "Pigment" plant in Leningrad. The number of layers and their thickness depend on the climate and on the vulnerability of the surface, a total thickness of 150-300 um being adequate in critical areas such as connectors to low-pressure, medium-pressure, and high-pressure cylinders. Tables 1; references 3: all Russian.

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CSO: 1861/511

UDC 621.313.62-752.001.24

LOW SPATIAL FREQUENCY MAGNETIC STRESS FORCES IN MULTIPLE-POLE ELECTRIC MACHINES

Moscow ELEKTRICHESTVO in Russian No 4, Apr 86 (manuscript received 30 Jul 85) pp 43-45

[Article by V. A. Tsvetkov, Doctor of Technical Sciences, All-Union Scientific Research Institute of Electricity]

[Abstract] It was recently shown that amplitude modulation of induction in the air gap represents a significant source of vibration in multiple-pole electric machines. This article presents a general analysis of the influence of stator core junctions on induction in the air gap of such machines, estimates the additional components of magnetic stress and on this basis analyzes some individual examples, particularly a case in which the number of junctions between hydraulic generator stator core sectors is significantly less than the number of pairs of poles. References 6: Russian.

6508/12947
CSO: 1861/496

UDC 621.165.620.193.1

WAYS TO REDUCE EROSION OF BLADES OF HIGH-POWER STEAM TURBINES IN THERMAL ELECTRIC AND NUCLEAR ELECTRIC POWER PLANTS UNDER CONDITIONS OF LOW FLOW RATE

Moscow ENERGOMASHINOSTROYENIYE in Russian No 4, Apr 86 pp 2-7

[Article by P. V. Khrabrov, candidate of technical sciences, V. A. Khaimov, candidate of technical sciences, and V. A. Matveyenko, candidate of technical sciences]

[Abstract] In order to ensure reliability of the low-pressure cylinders in high-power steam turbines during starting, idling, or massive steam diversion for heating, when the flow rate remains low, it is necessary to effectively cool the passages and the exhaust tubes while inhibiting erosion of the runner blades along their edges. The principal three methods of passive cooling are steam dumping, condensate injection, and mechanical atomization. The principal four methods of active cooling are feeding steam to the inlet of the low-pressure cylinder, bleeding from the low-pressure cylinder, passing steam through hollow guide vanes, and boundary cooling. Each method has its advantages realizable depending on the turbine construction, but each also introduces a source of erosive moisture and requires specific countermeasures. An analysis of the problem of cooling and erosion, specifically in thermal electric and nuclear electric power plants, indicates that the selection of cooling method best suitable for turbines of a particular construction and make (Leningrad Metal Works, Turboatom Works, Turboengine Works) is also based on feasibility of optimum erosion inhibition either technologically or structurally. Technological means include optimization of turbine starting and of steam dumping or condensate injection, effective blade inspection and flaw detection, reliable recording and statistical analysis of blade wear, optimization of overhaul procedures and blade edge reconstitution, organization of discharge from both upper and lower condenser compartments. Structural means include design of safe condensate injectors, maneuverable steam collectors, geometrical optimization of exhaust tubes and with effective demoisturization, gasodynamical optimization of the "condenser - exhaust" system, design of economic and safe active cooling system. Figures 3; tables 2; references 5: all Russian.

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UDC 621.224

MAJOR TRENDS AND PROSPECTS OF DEVELOPMENT OF HYDRAULIC TURBINE BUILDING

Moscow ENERGOMASHINOSTROYENIYE in Russian No 5, May 86 pp 2-3

[Article by Candidate of Technical Sciences O. S. Babanov and Engineer V. V. Kochan]

[Abstract] Major trends for hydraulic turbine construction over the next 15 years include: creation of maximum size hydraulic turbines for large hydroelectric power plants; development of series of powerful pump-turbines for pumped storage power plants in combination with nuclear power plants; creation in the near future of powerful pumps and large horizontal hydraulic machines for utilization of tidal energy sources; development and series production of standardized hydraulic turbine units for smaller hydroelectric power plants; and modernization of hydraulic turbine equipment of existing hydroelectric power plants. The power capacity of variable pitch turbines will be increased. Large pump-turbines will be installed primarily in the European USSR, where the construction of nuclear power plants requires pumped-storage facilities for faster response of power output to demand. The plans for development of hydraulic machine building set forth serious problems for researchers in this area of industry. Research must be undertaken on the creation of highly effective giant turbine units for planned super-powerful hydroelectric power plants. This will require an increase in the capacity of the experimental departments of institutions in this area.

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UDC 621.224

NEW LINE OF LARGE VERTICAL VARIABLE-PITCH AND RADIAL-AXIAL HYDRAULIC TURBINES

Moscow ENERGOSMASHINOSTROYENIYE in Russian No 5, May 86 pp 4-8

[Article by Candidates of Technical Sciences I. M. Pylev, L. F. Abdurakhmanov and A. A. Sotnikov]

[Abstract] A new hydraulic turbine line has been developed, a complex of standards and technical documents establishing systems and types of hydraulic turbines, their areas of application, major parameters and dimensions, and also containing information for the selection of hydraulic turbine equipment considering maximum economic effectiveness and reliability. The history of previous similar documents is traced. The new list includes universal characteristics of 32 types of impellers with improved efficiency over previous models. A table presents the basic geometric and hydraulic parameters of variable pitch hydraulic turbines on the list. The creation of a new standardized series of high efficiency hydraulic turbines, supporting selection of turbines for construction of hydroelectric power plants for virtually any head,

is a significant contribution to the nation's power production program. Figures 3, references 4: 2 Russian, 2 Western.

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CSO: 1861/388

UDC 621.224:539.4

NEW NORMS FOR PERMISSIBLE STRESSES IN HYDRAULIC TURBINE PARTS

Moscow ENERGOMASHINOSTROYENIYE in Russian No 5, May 86 pp 8-10

[Article by Candidate of Technical Sciences A. Ya. Aronson, Engineers V. Ye. Babachenko and Ye. M. Kagan, and Candidate of Technical Sciences G. Kh. Frank-Kamenetskiy]

[Abstract] Research performed by the Leningrad Metals Plant in connection with the creation of hydraulic turbine equipment has allowed a better-founded approach to determination of strength reserves for a number of hydraulic turbine parts and units. Equations are presented for calculation of required strengths of hydraulic turbine parts, including those exposed to corrosive fresh water. It has been found by many years of experience that the permissible stress standards of 1969 can be safely exceeded in some cases. The new equations reflect this experience.

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UDC 621.224.7

DESIGN OF PUMP-TURBINES FOR HEADS OF UP TO 120 M

Moscow ENERGOMASHINOSTROYENIYE in Russian No 5, May 86 pp 10-14

[Article by Engineers M. M. Kashirin and K. P. Lapshinov]

[Abstract] A pump-turbine unit consists of the pump-turbine itself, a regulator, and the automatic control equipment. This article describes the design of pump-turbine units designed to operate at heads of up to 120 m, intended to operate as turbines 3-5 hours per day, pumps 5-6 hours per day, and as synchronous compensators 13-16 hours per day, with multiple switching cycles during the course of the day, for use in pumped-storage hydroelectric power plants. These pump-turbines represent a new type of hydraulic turbine equipment, the creation of which requires significant research in all stages of planning. Drawings are presented of the major elements. Figures 5.

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NEW DESIGNS OF HYDRAULIC TURBINE UNITS

Moscow ENERGOMASHINOSTROYENIYE in Russian No 5, May 86 pp 14-15

[Article by Engineer A. F. Volkov]

[Abstract] In 1984, Leningrad Metals Plant completed planning and laboratory testing of a new design for seals of the vanes of turbine impellers for Saratov Hydroelectric Plant. This article briefly describes the new design plus a variable-pitch impeller in which the internal cavity of the hub is isolated from the oil of the regulation system to exclude oil leaks into the water, a bearing in which reliability is increased by rigidly attaching segments to the body of the bearing using water as lubricant, an oil receiver intended to avoid the problem of rapid wear of bronze bushings, and a hydraulic turbine shaft facing system for water-lubricated turbine shafts. Figure 1, references 2: Russian.

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UDC 621.224.002

IMPROVING HYDRAULIC TURBINE MANUFACTURING TECHNOLOGY

Moscow ENERGOMASHINOSTROYENIYE in Russian No 5, May 86 pp 15-19

[Article by Engineers A. I. Goldfarb and R. K. Fasulati]

[Abstract] Various steps can be taken to make the manufacture of hydraulic turbine parts less expensive in terms of both labor and materials. This article discusses such aspects as selection of optimal methods of forming of blanks to be used in manufacture, reducing the total length of the manufacturing cycle and the shop floor area required for manufacture, separate working of surfaces in turbine shaft flanges and generator hubs, avoiding simultaneous assembly of welded metal volute chambers and increasing manufacturing accuracy as a means of reducing labor consumption. Figures 4, references 5: Russian.

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UDC 621.224.35

SPECIFICS OF INSTALLATION OF LARGE HYDRAULIC TURBINES

Moscow ENERGOMASHINOSTROYENIYE in Russian No 5, May 86 pp 19-23

[Article by Engineers V. M. Zabelkin, Ye. V. Balagurov and V. A. Kudakov]

[Abstract] In the manufacture of large hydraulic turbines, some elements are manufactured and assembled by methods which reduce the amount of factory manufacture while actually increasing the amount of precision assembly and installation required in order to achieve required accuracies, anticorrosion and anticavitation properties or for other reasons. Under these conditions installation is not simply assembly, but rather represents a continuation of the manufacturing process. Examples of such cases are presented, indicating the scale of installation operations in modern large hydraulic turbines. Effective distribution of testing and assembly operations between plant shops and field installation areas must be based on economic expediency for the entire manufacturing and installation cycle. Labor consumption and cost of installation can be reduced by the use of fully interchangeable parts manufactured under rigid tolerances, eliminating possible deformation during construction and installation work at the power plant by increasing the weight and strength of structures, but this method is not always economically justified or even possible. Figures 5.

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UDC 621.224-52

MODERN AUTOMATIC CONTROL AND REGULATION SYSTEMS FOR HYDRAULIC SYSTEMS AND PUMP-TURBINES

Moscow ENERGOSMASHINOSTROYENIYE in Russian No 5, May 86 pp 23-26

[Article by Engineers V. S. Lychak and L. A. Klyavin]

[Abstract] The Leningrad Metals Plant has created a system for automatic control of hydraulic turbine equipment based on the use of modern equipment and apparatus produced by the Soviet electronics industry. The system includes an electrohydraulic rotating speed regulator, oil pressure installation and automation equipment. Further development of the automatic control and regulation system is proceeding in the direction of introducing more modern devices, as well as the use of basically new control and regulation circuits, satisfying today's requirements for the operation of hydraulic turbine equipment. The functioning of the system is briefly described and a block diagram of the regulator is presented. Work is continuing on further development of the turbine automatic control system by introduction of microprocessor technology. Figures 2, references 2: Russian

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UDC 629.7.036.3:621

COOLING OF BLADES IN GAS TURBINES AND DEPENDENCE OF ITS EFFICIENCY ON STRUCTURAL AND TECHNOLOGICAL DESIGN FACTORS

Moscow TEPLOENERGETIKA in Russian No 7, Jul 86 pp 27-30

[Article by S. Z. Kopelev, doctor of technical sciences, M. N. Galkin, doctor of technical sciences, A. N. Boyko, candidate of technical sciences, and I. V. Shevchenko, engineer, Moscow Institute of Aircraft Technology]

[Abstract] An experimental study of the cooling of blades in gas turbines was made, for the purpose of determining the dependence of its efficiency on structural and technological factors. The two structural factors of concern were spatial configuration of orifices in the insertable baffle for a runner blade sheath. Measurements were made by the method of local calorimetry in a liquid-metal thermostat, a blade with intake and exhaust for cooling air and initially at room temperature being immersed in superheated melt of pure zinc at 713 K and cooled together with the metal down to 692.4 K, the recrystallization temperature of zinc, while cooling air was blown through the blade for 10-15 s. These measurements have yielded rates of internal heat transfer and, with the blade form factor taking into account, the rates of heat transfer not depending on the turbine operation. The data were further evaluated, on the basis of applicable heat transfer equations, for a determination of heat transfer conditions at various blade segments from root to periphery. The results confirm the need for precisely monitoring the thermal characteristics of blades during their casting and subsequent machining so as to ensure predictability of their behavior in the assembled structure and to facilitate optimization of the cooling process. Figures 3; tables 1; references: 6 Russian.

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UDC 621.224

TRANSIENT LOADS ON GUIDE BEARINGS IN RADIAL-FLOW WATER TURBINES

Moscow ENERGOMASHINOSTROYENIYE in Russian No 6, Jun 86, pp 8-9

[Article by V. A. Kovalenko, candidate of technical sciences, B. M. Zhagrin, engineer, and S. N. Yavits, engineer]

[Abstract] A study of radial forces acting on the segments of guide bearings in vertical radial-flow [Francis] water turbines during normal operation was made, with dynamometer plates mounted in the bearings of two identical R0140 turbines and of two identical R0230 turbines. Strain-gage resistors were connected in a half-wave bridge circuit feeding an amplifier for recording of signals by an oscillograph or a magnetograph on tape. Pulses from a marker on the turbine shaft provided the time base and the reference for synchronization of signals. A frequency analysis of signals representing the

X and Y projections of the total load force as functions of time over a period of several shaft revolutions has made it possible to extract the dynamic part of that force. It consists of two components, one of a frequency equal to the shaft speed produced by a random distribution of runner unbalance and flow nonuniformity, and one of a frequency much lower than the shaft speed produced by the revolving vortex trail in the twisted stream behind the turbine runner. The static part of the total load on the guide bearing of a turbine is a hydrodynamic force produced by axial asymmetry of flow between guide vanes and runner, in seals, and behind the runner. All coefficients necessary for calculating these load components have been determined from the experimental data. Figures 1.

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METHODS OF REDUCING CAVITATIONAL EROSION IN RADIAL-FLOW WATER TURBINES

Moscow ENERGOSMASHINOSTROYENIYE in Russian No 6, Jun 86 pp 10-14

[Article by N. I. Pylayev, candidate of technical sciences, Yu. N. Liukonen, engineer, S. M. Bukchin, engineer, V. N. Stepanov, engineer, and A. M. Livshits, engineer]

[Abstract] A major problem in the design of high-power water turbines is lowering the rate of cavitational erosion throughout the runner. An analysis of theoretical pressure diagrams, based on the solution to the problem of axisymmetric three-dimensional flow and on the solution to the inverse problem of cavitationless flow past an array of foils, has revealed three main rarefaction regions within the blading ring: 1. immediately behind the vertical segment of the leading edge, 2. at the lower rim behind the leading edge, 3. between the trailing edge and the lower rim. Each region consists of a pressure-drop zone followed by a pressure-rise zone, with erosion generally occurring the latter. Precise delineation of the cavitation regions and their erosion zones is possible on the basis of model tests, which also yield the ranges of flow rate and runner speed favorable to cavitational erosion. Such a model study was made at the Leningrad Metal Works, with two layers of a special fragile varnish developed at the All-Union Scientific Research Institute of Hydraulic Machines for coating the blades of model turbines. The corrosion rate was measured at various constant runner speeds, flow rates, pressure heads, under equal static and fatigue loads, till the coating had been worn away down to bare metal. In another study was established the correspondence between runners of model turbines and runners of prototype turbines such as the RO230 manufactured at the Leningrad Metal Works, also the dependence of the erosion rate on the draught as well as the correlation between impact-wear characteristics of the special varnish and those of the oxide surface layer on carbon steel and of corrosion-resistant steels. The results indicate that 10Cr14Mn12N, steel has a much higher cavitation resistance than chromium steels and chromium-nickel steels. It is

not necessary to make the whole blade of corrosion-resistant steel, however, only to protect its surface within the cavitation region. Figures 5; tables 1; references 3: all Russian.

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DESIGN AND PERFORMANCE ANALYSIS OF PROPELLER-TYPE WATER TURBINES FOR IOVSKAYA GES

Moscow ENERGOMASHINOSTROYENIYE in Russian No 6, Jun 86 pp 14-16

[Article by A. F. Volkov, engineer, P. A. Murzin, engineer, A. P. Nikiforov, engineer, and I. D. Chistyakov, engineer]

[Abstract] Propeller turbines are now being constructed at the Leningrad Metal Works for installation in hydroelectric power plants, such turbines being most suitable as components of large power systems or where several of them operate under an only slightly fluctuating pressure head. A design and performance analysis has revealed that it is feasible to replace the PL577 radial-flow runners in existing 41.5 MW turbines in the Iovskaya GES with PR40/800 propellers (nominal diameter 4500 mm, number of blades 6, blade setting angle +12°, nominal speed 136.4 rpm, number of guide vanes 24, net pressure head 34 m maximum and 30 m minimum, power 50 MW at nominal 32 m pressure head), without modifying the volute chamber and the draft tube. The power will thus increase by 20% and the efficiency should increase by approximately 2%. Pressure fluctuations must be reduced, however, for which injection of atmospheric air through the clearance under the turbine housing is proposed as an effective measure. These conclusions are based on model and prototype tests as well as on theoretical efficiency and pressure calculations, without and with air injection. Dynamic stresses and vibrations still remain a problem, but stiffer mounting of the blades and undercutting them at the periphery near the back edge as well as strengthening the welded joints by superficial plastic deformation will solve it. Figures 5.

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PROBLEMS IN AUTOMATING EXPERIMENTAL STUDIES

Moscow ENERGOMASHINOSTROYENIYE in Russian No 6, Jun 86 pp 19-21

[Article by M. V. Gushchin, engineer, and V. F. Sidorenko, candidate of technical sciences]

[Abstract] Automation of scientific experimental studies necessary for design and construction of new hydraulic machines is proceeding in several

stages, some phases of the automation system having already been completed. The first level of this automation system is control of measuring processes, data gathering, primary processing, and recording during power and cavitation tests performed on models of water turbines and pump-turbines. The hardware includes test-stand instrument transducers for primary conversion of mechanical and other quantities into frequency-modulated electric signals, nine SM1-5 minicomputers, power supplies, communication lines from transducers and recording instruments to computers, and calibrating equipment. Both hardware and software were developed for pump and turbine testing, and was checked in each mode. A theoretical and statistical analysis of the results indicates that this first level of automation not only functions properly but also improves both accuracy and reliability of tests. Analogous subsystems with appropriate hardware including an SM1-5 minicomputer each are to facilitate automation of static tests for mechanical strength performed with strain gages and a digital bridge on turbine parts and assemblies, automation of tests performed on radial-flow and axial-flow runners for determination of hydraulic forces acting on the blades, automation of tests performed on water turbine and pump-turbine models for determination of flow rates by the weighing method, and automatic monitoring and control of test mode stability. The second level of automation is control of the first level and secondary data processing, with appropriate hardware and software, also formation of a unified data base and facilitating data exchange in real time, for automatic plotting of dimensionless performance characteristics, for automatic calculation of radial bearing loads, and for automatic spectral and statistical correlation analyses of transient processes, including numerical integration. As development of this automation system is being completed, care must be taken to ensure compatibility of software and hardware at all levels and to provide for future expansion and additions. Figures 3.

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UDC 621.224.001:65.011.56:681.3

BASIC PRINCIPLES OF CONSTRUCTING COMPUTER-AIDED DESIGN SYSTEM FOR HYDRAULIC MACHINES

Moscow ENERGOMASHINOSTROYENIYE in Russian No 6, Jun 86 pp 21-24

[Article by V. Ya. Gutkhen, engineer, S. Ya. Ilin, engineer, Yu. S. Kondratyev, engineer, and V. I. Sonin, engineer]

[Abstract] In the course of changeover to computer-aided design (CAD) at the Leningrad Metal Works, software has been developed for solution of various engineering problems. The CAD system for water turbines contains four subsystems: "flow channel", "volute chamber - stator", "guide ring" and "turbine hydrodynamics". Each solves layout, dimensioning, evaluation, graphical and textual representation problems as well as special problems applicable to the particular turbine component. The "flow channel" subsystem uses a set of diparametric bicubic splines describing the performance characteristics, based

on dimensions of the model turbine and a 5% overload capacity. The "volute chamber - stator" subsystem solves all problems pertaining to hydrodynamics and mechanical strength in this turbine component, including development onto a plane, selects the key points and calculates their coordinates as well as the dimensions of all parts on the basis of the given flow rate and stator geometry. The "guide ring" subsystem calculates the vane setting angles, the kinematic characteristics of the guide ring and the hydraulic loads on the vanes, also the mechanical strength of vanes and the servomotor power requirement for vane adjustment. The "turbine hydrodynamics" subsystem solves the fundamental design problem, namely optimizes the flow channel and the runner for maximum efficiency. Use of this CAD system has already yielded an economic effect in terms of better quality of produced turbine parts with much less waste. Figures 3.

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RESEARCHING SERVICE CHARACTERISTICS OF MATERIALS - BASIS FOR IMPROVING RELIABILITY AND LIFE CHARACTERISTICS OF GAS TURBINES

Moscow ENERGOMASHINOSTROYENIYE in Russian No 6, Jun 86 pp 25-30

[Article by V. V. Rtishchev, candidate of technical sciences, P. V. Khrabrov, candidate of technical sciences, and Yu. G. Korsov, candidate of technical sciences]

[Abstract] Inasmuch as a substantial improvement of gas turbines depends on the possibility of operating at higher initial temperatures, a great deal of research is done on materials capable of withstanding higher temperatures up to 1000°C as well as chemically aggressive fuel, combustion products, and condensate. The principal materials under consideration are steels for runner blades. Steels of the EI class (607, 765, 893, 893 cast) and of the ZhS heat-resistant class (ZhS6K) now used have been extensively studied for ways to improve their microstructure and consequently their mechanical characteristics under more severe operating conditions, while other steels in the EP class and the corrosion-resistant TsD and TsZh classes have been selected as promising alternatives. It has been established so far that the existing steels need to be protected by anticorrosion coating or replaced by more corrosion-resistant grades. Casting into single crystals or high-speed directional crystallization for communition of dendrites are promising technological methods of attaining better service characteristic, applicable also to altogether new materials such as ceramic and powder composites. Figures 2; tables 4; references: 16 Russian.

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TECHNICAL AND ECONOMIC VALIDATION OF OPERATING STANDARD LOW-PRESSURE CYLINDERS IN STEAM TURBINED AT HIGHER POWER LEVEL ON BASIS OF FUNCTIONAL AND COST ANALYSIS

Moscow ENERGOMASHINOSTROYENIYE in Russian No 6, Jun 86 pp 36-39

[Article by N. G. Bulanov, candidate of economic sciences, L. N. Moiseyeva, candidate of technical sciences, O. L. Golovanov, engineer, and N. G. Baskakova, engineer]

[Abstract] A functional and cost analysis of standard low-pressure cylinders for steam turbines has been made at the Central Institute of Boilers and Turbines, for the purpose of validating their operation at higher power levels. A low-pressure cylinder is treated as a technical entity and also as a component of electric power plant and thus of a fuel-energy system impacting on the national economy. The object of this functional and cost analysis was to determine the type sizes of low-pressure cylinders which will ensure the necessary degree of adaptation to power units running on nuclear or fossil fuel at a minimum cost under conventional but variable constraints on available metal and labor. The analysis was based on a dynamic design optimization model and on given power levels attainable within a given five-year period with given turbine-generator sets. The analysis was treated as a problem of linear programming and the essential design characteristics of a low-pressure cylinder as well as the performance characteristics of its turbine under new conditions. The results of this analysis indicate also the optimum design strategies for maximum metal eocnomy. Numerical input and output data apply to thermal electric and nuclear electric power plants in the European part of the USSR. Figures 3; tables 1; references 6: all Russian.

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MATCHING PARAMETERS OF SUCTION SCREW AND IMPELLER IN COMPOUND STAGE OF ROTARY PUMP

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian No 6, Jun 86 (manuscript received 23 Dec 85) pp 87-91

[Article by I. V. Matveyev, candidate of technical sciences, docent, L. A. Vasilenko, candidate of technical sciences, and V. G. Tazetdinov, graduate student]

[Abstract] The performance of a compound rotary pump with a suction screw preceding the impeller on a common shaft is analyzed, conditions being determined which will ensure cavitation-free operation of the impeller. These conditions depend on the screw, which already cavitates, and the

pressure head it develops for the impeller. Calculations take into account the finite thickness of impeller blades but disregard friction in the interstage channel. An analysis of the flow characteristics and geometry reveals that the screw does not necessarily match the impeller hydrodynamically, even when it develops a high pressure head. Its effect on the impeller and the need for matching it are therefore important factors in the design of a compound pump for better performance. Figures 2; references 7: all Russian.

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PERIPHERAL CROSS-SECTION AND SPECIFICS OF ITS PLANNING IN THE PROCESS OF CREATING TURBINE BLADES OF MAXIMUM LENGTH

Kiev PROBLEMY MASHINOSTROYENIYA in Russian No 24, Dec 85 (manuscript received 20 Jan 84) pp 70-78

[Article by A. A. Tarelin and V. P. Kryzhenko, Institute of Machine Building Problems, Ukrainian Academy of Sciences, Kharkov]

[Abstract] A very important and difficult stage in the planning of the upper cross-sections of turbine blades of maximum length is ensuring that the final blade is driven, when the design of the tail section is of herringbone type. Therefore in calculating the profiles of blade cross-sections, the driving of the last blade must be tested, requiring initial calculation of the radius of curvature and the coordinate of its center as a function of the design of the tailpiece of the blade. An equation for this purpose is presented. Sixteen profile versions, their characteristics and limitations are computed. The method suggested for selecting an effective profile by computer calculation allows rapid and effective determination of the best peripheral profile version, a basis for planning of the final blade for the last stages of high-power steam turbines. Figures 5, references 4: Russian.

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EXPERIMENTAL DETERMINATION OF MECHANICAL AND VOLUMETRIC LOSSES IN A PUMP-TURBINE MODEL

Kiev PROBLEMY MASHINOSTROYENIYA in Russian No 24, Dec 85 (manuscript received 23 Apr 84) pp 88-98

[Article by I. M. Pyliov, A. A. Sotnikov, A. K. Malishev, Ye. A. Matyushicheva and A. N. Yevdokimov, Leningrad Metals Plant]

[Abstract] In the process of studying a pump-turbine model at the Leningrad Metals Plant, experimental data were obtained on mechanical and volumetric

losses. The mechanical losses were determined on an experimental installation allowing determination of the moment of friction with the water of each element of the outer surface of the drive wheel. The experimental installation allows direct measurement of torque on any element of the surface, duplication of measurement by two different measurement instruments, preserving the shape of the major elements of the outer surface of the drive wheel the same as in the actual model, and the use of the identical working fluid as the pump must actually drive. The installation does not completely model the operating process, since there is no flow in the meridional plane along the lower edge of the drive wheel resulting from leaks. However, the influence of the flow on friction can apparently be ignored, the meridional component representing only a few percent of the circumferential component of velocity. The experiments showed little change in volumetric efficiency in the two operating modes. The mechanical efficiency in turbine mode increased significantly with a decrease in adjusted rotating frequency and an increase in adjusted throughout. In pump mode it changed little since in the pump mode power consumption changes little around the optimum, whereas in turbine mode power generated is directly proportional to both head and flow. Figures 3, references 3: Russian.

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DEVELOPMENT AND INVESTIGATION OF RATIONAL METHODS AND DEVICES FOR THE USE OF HYDROGEN IN GAS TURBINE MOTORS

Moscow MIKROELEKTRONIKA in Russian Vol 15, No 2, Mar-Apr 86 (manuscript received 19 Sep 83) pp 104-108

[Article by P. M. Kanilo, Institute of Machine Building Problems, Ukrainian Academy of Sciences, Kharkov]

[Abstract] The author's Institute has developed and tested several basic methods for the application of hydrogen in gas turbine motors. These include addition of small quantities of hydrogen to the combustion chamber to promote processes of combustion of the major hydrocarbon fuel, particularly during startup and under low power conditions; as an atomizing component for the basic liquid hydrocarbon fuels; as an inhibiting component to prevent formation of carcinogenic substances during combustion of hydrocarbon fuels, particularly fuels with a ratio of hydrogen atoms to carbon atoms H/C less than 1.8; as a fuel for brief use under special conditions; as a stabilizing energy-carrying fluid in homogeneous 2-stage and hybrid methods of combustion of hydrocarbon fuels; and as a main or supplementary energy carrier activated in hydride sprayers before being fed into the combustion chamber. The physical and chemical bases of effective utilization of small quantities of hydrogen in power installations with gas turbine engines are noted, particularly upon implementation of homogeneous, 2-stage and hybrid combustion of 2-component hydrocarbon-hydrogen fuel. Figures 3, references 6: 5 Russian, 1 Western.

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SINGLE-POLE MOTORS WITH MULTIPLE-DISK ROTOR IMMERSED IN LIQUID METAL

Moscow ENERGETIKA I TRANSPORT in Russian No 1, Jan 86 (manuscript received 6 Sep 84) pp 163-166

[Article by S. A. Vasilyev, G. N. Perelshtein and Yu. A. Sozinov, Novosibirsk]

[Abstract] The use of circular liquid metal slipping contacts of traditional design in large single-pole D. C. motors involves significant technical difficulty due to the large number of series connected contacts, each of which must have a separate liquid metal circulation circuit. Preference is given to a design in which a multiple-disk motor rotor is completely immersed in liquid metal. The MHD losses in such a device can be determined by experimental study only. This article presents such a study, performed on an installation consisting of a model of a single pole motor connected to a DC machine and a liquid metal circulation circuit with an argon vacuum system. The experimental data obtained were used in the design of a series of single-pole motors with multiple-disk rotors immersed in liquid metal operating in the 2.5-30 MW power range with operating speeds of 75 and 150 RPM. The results indicate that these motors are equal in efficiency to commutator machines, and when used in place of commutator machines in a controlled electric drive system can yield a significant economic effect resulting from the lack of switching difficulties and an increase in reliability, as well as the possible further increases in unit power of machines while significantly reducing the inertia of the motor. Figures 5, references 8: 4 Russian, 4 Western.

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COMPUTER MODELLINC OF THE HEAT FIELD OF A POWERFUL CRYOTURBINE GENERATOR MOTOR

Moscow ENERGETIKA I TRANSPORT in Russian No 1, Jan 86 (manuscript received 4 Jul 84) pp 163-166

[Article by G. M. Khutoretskiy, V. D. Varshavskiy and I. A. Tsukerman, Leningrad]

[Abstract] A universal algorithm is used for thermal design calculation of a 2-dimensional rotor model, allowing consideration of the assigned geometric and heat physical properties of all structural elements without significant simplifications. The calculated temperature distribution allows analysis of the thermal conditions of the rotor in various design versions. The theory of difference systems is used assuming homogeneity of the heat field in the tangential direction, yielding a 2-dimensional problem. The universality of the method allows a single algorithm and program to be used to calculate

various versions of design of the individual parts, as well as the entire rotor. The method allows calculation of the temperature field of the rotor and heat fluxes into the cold zone for various designs and various operating conditions of the cryoturbine generator. The use of the Newton method significantly decreases machine time and memory capacity requirements. This allows multivariate calculation for estimation of optimal rotor design parameters. Figures 3, references 5: Russian.

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